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NEW HARMSWORTH SELF-EDUCATOR

EDITED BY ARTHUR MEE

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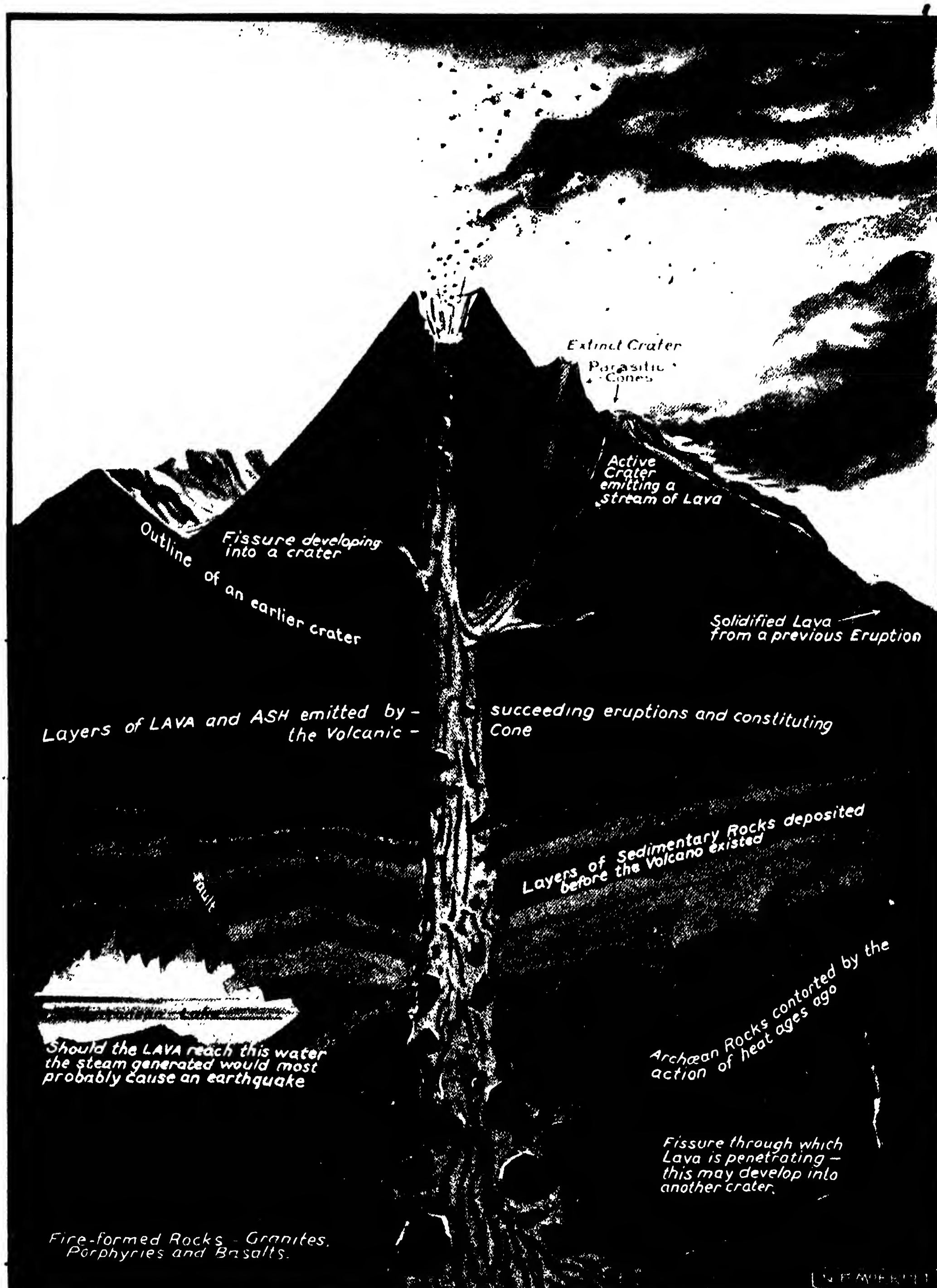
THE ESCAPE OF EARTH'S IMPRISONED FIRES



A PICTURE DIAGRAM OF A SECTION THROUGH A VOLCANO

This drawing illustrates all the chief characteristics of volcanoes of the Vesuvian type. In this example we have a new cone forming in the bed of an earlier crater. Smoke and ashes are belching forth from the active central crater and a stream of lava is pouring out of a parasitic cone.

Ideas that have Changed the Face of the World.
Shrewd Observation the Basis of Inspiration.

THE MAN OF IDEAS

THE world is ruled today, as it ever has been ruled, by the men of ideas. Behind the thrones of the Great Powers they stand, directing the hand which nominally wields the sceptre. In the Great Republics the men with ideas are they whom the nations choose. In all lands where government is pure and for the greatest good of the greatest number, the high offices of State are held by the men gifted with brains.

Lineage and academic distinction shrink to insignificance in the fires of modern competition. The possession of ideas has become a man's richest asset, provided always that he has the practical turn of mind rightly to apply them.

No man can command the birth of an idea. They come and they go, these will-o'-the-wisps, and no man knows whence nor whither. Their advent may be wholly without the volition of the brain in which they are born; it is for the brain to see to their retention and use. Men's minds vary in degree of receptivity and retentiveness, as one photographic plate differs from another. For one plate the merest glimpse of light suffices it to record an object within its focus, no matter how swiftly that object moves; the other needs long exposure and steady light before an impression can be received. Both plates are essential to the photographer's art—the one for rapid movement, the other for still-life, dim interiors, and detail.

So it is with men. To some, ideas come, complete in every particular, like an inspiration—a melody which shall sound throughout the world, a revolution in mechanics, in locomotion, in abstract science. Another man, the movement of whose mind no stimulus can accelerate, assimilates an idea by laborious mental process, but brings it in the end perfect to its work. So we find the broad line dividing the genius from the plodding, unwearying thinker, the poet from the cautious philosopher, the Browning from the Gray, the Macaulay from the Herbert Spencer, the Edison from the Singer, the man of a myriad schemes from the man of one grand idea, slowly and with vast effort won from nebulous gleams to coherent reality.

Life runs so smoothly now, that originality, the superficial think, cannot possibly deflect its course to ways still smoother. So the superficial thought in all ages, deriding and persecuting the pioneers of change. But history teaches that the revolutionary and the visionary of today, in science, in commerce, in politics, are apt to be found least advanced among the men of to morrow. The discovery of the possibilities in steam accomplished a greater advance for civilisation than anything previously done for the improvement of locomotion from the beginning of time. Sir Robert Peel travelled from Rome to London to form a Government exactly as Constantine had travelled from York to Rome to become Emperor. Each traveller had all that sails and horses could do for him, and no more. A few years afterwards the humblest steerage passenger had at his disposal the means of reaching Rome from London within a few hours. It was the result of an idea.

The basis of the idea was not new. Two thousand years before, Hero, the mathematician of Alexandria, had designed the first steam-engine. It was an idea which enabled Napoleon to throw an army—horse, foot, and artillery—across the Alps, and, sweeping like a hurricane down upon Italy, to lay her conquered at his feet. Here was another idea which had lain dormant since two hundred years before the dawn of the Christian era, when Hannibal, with horses, elephants, and 90,000 men, crossed, first the Pyrenees, and then the Alps. A new idea in naval attack gave Nelson the victory of the Nile, and enabled him to form those plans which swept the French and Spanish fleets from the sea.

There is no phase of life in which the fertile mind does not lift its master above his fellows. Year after year surgeons practising in all the cities of Europe contrived, by operations, more or less to relieve affections of the ear. One day an accident occurred; a Viennese surgeon made too deep an incision and cut the bone. By a happy mischance a new and

important operation was discovered. He seized the idea. Years of experience had failed to impress him with the obvious advantage thus forced upon his notice by an accident seemingly unfortunate.

Ideas are begotten, very often, of suggestion. There are suggestions everywhere for the eye which sees. Nature is still the great teacher if we can but read her lessons. What relation can there be between a tree and a lighthouse; between a leaf and a revolution in architecture? Monumental record exists today of a very close connection. The Eddystone Lighthouse, which has braved the fury of the waves for more than a hundred years, is modelled on the trunk of a tree. Winstanley's lighthouse had been destroyed by a storm, and Rudeyerd's by fire, when John Smeaton undertook to erect a successor. So narrow was the ledge of rock upon which to build that he determined the only course was to root his building after the manner of a tree. Just as the trunk is held in place by its roots deep down in the ground, so the foundations of the new Eddystone were sunk in the excavated rock, and fastened there by an ingenious dove-tailing. The Eddystone still stands, strong, immovable as ever, the model upon which all subsequent lighthouses in similar situations have been built.

The Crystal Palace, the latest national playground to be acquired for the nation, we owe, not to an architect, but to a gardener with ideas—Joseph Paxton. No man in England was able to furnish plans to meet the requirements of the building for the Great Exhibition, the purpose for which the Crystal Palace was constructed. Defects spoilt the most promising. Paxton overcame the difficulties. He had found his idea in his garden. An examination of the Victoria Regia had shown him the wonderful power of flotation possessed by the leaves of this plant, and the principle upon which this was contrived. What a plant could do, a man could imitate. The old and unsightly heavy ties and girders which architects had always been accustomed to employ were unnecessary. He showed by homely illustration the effect of his plan. A splinter of wood may be easily snapped if its ends be pushed towards each other, but a great force is required to pull the ends asunder So iron and glass came to take the place of wood and stone, and a new system of building was introduced—by a gardener.

From such insignificant sources do great creations spring. In the dust of the earth, in the industry of a worm, in the colours of a soap-bubble, the great mind finds that which aids him some way further to read the writings of eternal laws. This is no mere flight of fancy. In the very dust is an exquisite story of the marvellous provisions of Nature to give shadow and tint; in the soap-bubble Newton found that which gave it a legitimate place among the most curious of optical phenomena. And the worm? It taught us sub-aqueous tunnelling.

From the beginning of history the teredo or pholas, the soft white worm which lives in our harbours and the mouths of rivers, had pursued its destructive course, boring its way through the hulls of ships, eating the defences of harbours. Then there came Brunel, who, watching its operations, saw how he might construct his tunnel beneath the Thames. The worm, he learnt by close watching, encased itself in a calcareous tube of masonry as it bored its way into the timber. Here was the fountain of his engineer's idea. He set men to bore with rods into the mud from a shield, which was moved forward as they made their way, and a brick arch constructed in the rear, in exact imitation of the calcareous tube of the worm.

So the seeing man finds his inspiration. Lessons such as these are everywhere to be gleaned by the observant. Take another instance, not less romantic. The engineers who built the mighty breakworker at Cherbourg noted with what strength common mussels cement themselves together, adhering to rocks and stones or any solid substance which happens to lie about them. Taking advantage of this knowledge, they saved themselves the trouble of extending their submarine masonry indefinitely. They deposited in the sea at the proper places huge quantities of loose stones. Upon these they tipped tons of live mussels, knowing well that the shell-fish speedily would spin their string-like webs and so bind together the stones with a cement more durable than any man could make.

Paxton was not the only man of his generation who knew the mechanism of the Victoria Regia; Brunel was not the first to observe the process by which a soft, gelatinous worm made its way through oak timbers—their knowledge on these subjects was commonplace to the botanist

and the naturalist. It was the application of the idea which was startling. Ideas occur to man after man in successive generations and are wasted, until there is fashioned the mind which is productive as well as assimilative.

How can ideas be applied? That depends largely upon the circumstances of the individual and the nature of his scheme. There never was a better time than now, when greater scope was afforded for the carrying out of new projects. "The men for whom we look now with a view to possible partnerships are no longer those with capital," a prominent member of the House of Commons said to the writer. "We must have men with ideas capable of adequate expression in practical production." One man, a working plumber in a Kentish village, devotes his leisure at nights, and the scanty holidays granted him, to materialising ideas which occur to him in odd moments during his work. A year of nights he sacrificed to the fashioning of an appliance for soldering—a tiny mechanism which he carries in his waistcoat pocket—lamp and blowpipe combined, which enables him to dispense with the cumbersome brazier and melting-pot. Such a man, with increased opportunities, might prove a second Nasmyth, and give us a contrivance as important as the hammer with which the name of that genius is associated. The villager's inventions are his voluntary creations: Nasmyth invented his titanic hammer in response to the appeal of a man who could not otherwise get a forge hammer capable of producing the shaft which he needed.

As a rule, however, inspiration is an unwilling and unstable guest; it must be seized at once, before it may be too late. Coleridge dreamed his "Kubla Khan," and wrote in his waking moments the precious stanzas which he remembered. John Bright composed all his speeches in bed. Most of us, however, must look to periods of great mental alertness for the coming and thinking-out of ideas. And when they dawn upon our horizon they should promptly be noted down.

There may be value in the flimsiest notion. A man thinks of a metal tip for boots, and makes a fortune from it; another applies a piece of rubber to the end of a pencil. A third compounds a decoction which, smeared upon windows, prevents their "steaming" in cold weather. Another, of scientific bent, notes that a mineral refuse, thrown away as valueless, emits a strong odour when in contact with water, and the result is acetylene gas and all that that may yet mean as an illuminant. A trickling stream of mineral oil in a Derbyshire mining village was found by the first Lord Playfair to contain paraffin, and from his recognition of its worth sprang up the gigantic industry which in America has made fortunes hitherto undreamed of.

Every invention opens out fresh fields for other inventions, and the examples we have seen may stimulate thought in directions in which advance may still be made. Man sails the air and sails the seas, and hastens with the speed of the bird upon dry land. But in each phase of travel he is anxious still to do better. The electric train supersedes the steam-engine. The turbine steamer ousts the older form, just as the screw propeller gained the day against the paddle-wheel. Electricity and the motor claim the sphere of the horse for travel by road.

These are among the ideas newly utilised. The men in whose brains they took shape perform more notable service for mankind than the greatest general who ever slew a rival's forces. The compositor who sets up the type for the Bible, and the machinist who prints the pages, are greater forces for good than the wisest of the ancients. Those wise men of old, in the dim light which preceded the glow of learning whose glorious dawn our own day was to witness, had their splendid and noble ideas, ideas which live in architecture at which the world still marvels and cannot emulate. With their manual labour, and their implements of which the world has lost count, they fashioned their wonderful Sphinx, that, in spite of all that has since been achieved, remains the greatest stone monument in the world. Their enamels have outlived the shells of which they were but the veneer.

But the modern idea brings mightier things to pass than ever those wise men of the East could dream. We bridge rivers and straits and gorges which would have been impassable to them. We link ocean with ocean, and send our ships where they had not a waterway. We navigate seas which were to them unknown; we race at sixty miles an hour over lands whose existence was to them unimaginable, and we fly in the skies where they could

conceive of no life higher than the birds. The ideas of men have made a new world.

The significance of an idea can never be realised at the moment of its birth. The alchemists were the first to discover the readiness with which sulphur can be ignited, but they left their discovery at that. Meanwhile men, civilised and savage, sought their fire as men had sought it from prehistoric days. The savage rubbed wood; the civilised man plied flint and tinder as they had been plied from the dawn of the iron age.

Then came a simple Stockton chemist, to whom occurred the idea of making the first lucifer match from pieces of wood dipped in chlorate of potash and sulphur. At one bound the ages were left behind, and a distinct boundary between civilisation and savagery was established.

Even more notable was the advance made when the light of coal-gas first beamed forth upon the waters of the Thames from the pioneer lamps upon Westminster Bridge. The oil-lamp of the savage was rough and crude and filthy; that of the philosopher and warrior of cultured Greece and Rome beautiful and ornate, but both were the same in principle. British history in Parliament was all made by candle-light, or by the feeble flame of the bowl of fat and wick of fibre. Then a man's idea literally illumined the dark places of the cities of the world, and the electric light, wonderful as it is, was the less wonderful when it came, because of the manifold merits of its predecessor and rival.

These are facts which enable us, by contrasting the present with the past, to appreciate the power of ideas. The ships with which Nelson crushed the naval might of Napoleon were but developments of the war galleons of the primeval Norseman, and depended upon the principles on which the savage relies as he cuts his way through the waters of the silent rivers of South America or Africa. A single first-class ironclad of today would sink the combined fleets of Nelson and Napoleon. And men's brains are daily exercised to bring about new devices which shall render the present fleets of the world as useless as the old warships of oak.

When a thinker gives an idea to the world, he increases the intellectual capital of the race. He cannot say in what proportion profit will be reaped; he cannot always predict in what direction results will tend; he cannot, from his close-range view, see very clearly whether his discovery be a pearl of price or merely a day-dream, unworthy of permanent record He must put it to the test.

Alfred Russel Wallace, dreaming his feverish dreams in the Moluccas, was too modest a man to let himself believe that he had solved a gigantic problem when one afternoon there flashed in an instant upon his mind the idea of Evolution, the survival of the fittest, and the variation of species. That evening he drafted his theory; on the two subsequent nights he elaborated it. Then he posted off his notes to Darwin. Neither had guessed that the other was working on the subject; neither for a moment suspected that he was about to create a revolution in thought which was to rouse the whole civilised world to the highest pitch of excitement But Darwin, as we all know, was already engaged upon the work of his life, fearing, meanwhile, as he replied to Wallace at the time, that "my work will not fix or settle anything." He did fix and settle a great deal, as it was his privilege in after years to feel assured. But there are countless secrets yet to be rapped out of the stony bosom of Mother Earth. Darwin and Wallace, and their school, gave us the hammer wherewith to do the tapping.

As well by example as by precept, leaders of thought and action teach us how imperative it is alertly to act upon inspiration. Louis Pasteur, whose mighty brain was a magazine of ideas, impressed upon his students that, "in the field of observation, chance favours only those who are prepared." His own record is a signal exemplification of the power of an idea. What to the ordinary, unimaginative analytical chemist would be the significance of two vats of beer containing, the one sour beer, the other good? To Pasteur it meant the opportunity to revolutionise chemical and biological science. It meant to the world that a great and devastating pestilence was to be struck dead. The microscope revealed the fact that the globules of the sound beer were nearly spherical, while those of the sour beer were practically globular. Experiments showed that wine and beer and milk are turned sour by the growth of atmospheric organisms, and that when these are excluded the liquids remain sound. If wine and beer and milk can be

kept sweet when protected from putrefactive germs, why not other forms? Lord Lister seized upon Pasteur's discovery, and the antiseptic treatment for wounds was born.

Until then, anæsthetics, that Godsend to suffering humanity, had proved rather a curse than a blessing. In the days when operations had to be borne by conscious patients, the man with the readiest knife and strongest nerve was the most successful craftsman. A serious operation must be raced through, or not attempted. With greater leisure afforded for more extensive and delicate operations, the scope of the surgeons was enormously enlarged. But pestilence stalked in the wake of the new discovery. Gangrene became epidemic in the hospital wards of the world; in places it was attended by a mortality rate of over sixty per cent. after operations. With Pasteur's discovery developed by the master hand of Lister, surgery was revolutionised and no operation was impossible.

No person imagines that the birth of even so epoch-marking an idea as this constitutes a royal road to perfection of knowledge. The investigations of Pasteur and Lister read like a fairy-tale. Lister's, in particular, thrill with human interest as we see the great mind of the thinker groping from the dark into the light; see him win his first triumph over putrefaction of the wounds by the use of carbolic which caked upon the incision, and by the use of a spray which time proves unnecessary; then see him finally attain perfect mastery of the subject. With the antiseptic treatment added to anæsthetics no wound need now be declared hopeless, no organ of the system too remote or delicate for effective treatment.

Into the gravest research and study humour will creep. We laugh at the bizarre and fantastic ornaments of savages, yet a fashion of the early part of the Victorian era was found by the scientific mind of Dr. Buckland to depend upon a misconception more ludicrous than any embraced by travellers' tale or creation of the humorist. Beautiful women, society leaders, were wearing as charms, as earrings, bracelets, and what not, highly polished substances which were understood to be rare British minerals. Certain markings and other evidences gave the brilliant Dean of Westminster a clue, and led him to an analysis of the curious adornments. The result was as he had suspected. The charms and earrings, and so forth, set in gold and decorated with gems, were simply the fossilised excreta of extinct monsters by which our island was once inhabited. The discovery would have been startling and interesting to the archæologist, but nothing more, had it remained there.

To the ordinary mind there does not appear any clearly traceable connection between the earring of a society belle and a vast agricultural industry. But the second grew out of the first. Buckland recognised that in these age-old deposits, of which vast quantities were available in certain valleys and river-beds, were properties of value to agriculture. Liebig, the great German chemist, happened to be in England at the time, and the Dean took him to inspect the deposits. He saw at once that they must contain abundance of phosphate of lime. He took back some to Germany, and there made a careful analysis which bore out his theory. And from that discovery originated the great industry of super-phosphates, which has wrought such enormously important results for agriculture.

The field for great enterprises is still largely virgin soil. Men like Sir Norman Lockyer look to sunspots wherein to read the secret of famine and pestilence in India. Others keep their eyes upon the earth, and there win relief and benefit for the million. The story of Sir Clements Markham's introduction of quinine into India is one of a noble idea daringly, unfalteringly carried through. He had to procure the tree from Peru, and the dangers and difficulties attending his task were innumerable. But he succeeded, despite all perils, and has been allotted his place in history as having performed a service of the highest value to humanity. What it means may be estimated from the fact that, unless checked by quinine, malarial fever kills more people every year in Southern India than the worst of cholera epidemics. Now, quinine is the one sovereign specific against this deadly fever.

In spite of all that has been achieved, however, there remains much to be done in our tropical colonies. In India alone five million people died in 1900 from malarial fever; and there have long been more places than Sierra Leone meriting the description of "white man's grave." It remained for a soldier-scientist in Sir

Ronald Ross to elucidate the mystery of malaria and yellow fever; to show, after years of dispiriting effort, that the malaria germ enters the poison gland of the mosquito and is transmitted thence to the blood of the human being. The remedy is, so far, to do away with the swamps and marshes in which the mosquitoes breed —a campaign of cleanliness, sanitation, drainage. The remedy is primitive in its simplicity, but the idea which led to its discovery has given its possessor enduring fame.

When Sir Humphry Davy spoke of "radiating matter," he used a phrase which had no meaning for his generation. A century was to elapse before the idea developed fully in the minds of the gifted M. and Mme. Curie, who were to discover radium to the world. And then, at a bound, scientists were transported to a world whose border-lines had so long eluded them. Infinitesimal as are the quantities in which radium has so far been found, sufficient has come to hand to demonstrate the possibility of its revolutionising science. A competent authority has calculated that there is stored in a single grain of radium sufficient energy to raise 500 tons to a height of one mile, and for an ounce of it to drive a thirty-horse-power car round the world.

Its potentialities as an illuminant, too, seem boundless—even the blind are made to "see" its light. Most important of all, as a curative agency in disease radium seems destined to take a commanding place. Already certain forms of cancer have been cured by its aid, and we are still only at the beginning of our knowledge as to its wonder-working attributes.

Such are some of the ways in which the ideas of thoughtful men benefit the race, and, step by step, bring us nearer to the millennium. Every discovery begets other discoveries.

The day of the dreamer has gone. So many minds are applied to problems that, if the guerdon is to be secured, the man with an idea must see to it that none other comes before him in making plain his discovery. It is to the undying glory of European scientists that all their greatest discoveries are given without money and without price to the world. In America the custom is not always so chivalrous; the aid of patent law is invoked for discoveries in pure science which, if made in England, would be freely given to the people.

This, however, is a consideration which does not affect the many; the dividing line is sharply drawn between ideas upon which the world has a legitimate claim, and those whose profit should rightly accrue only to their originator. The point is that all who set themselves to the elucidation of problems, great or small, must seek without delay practically to apply them. Science must now be applied. The scientific recluse to whom his laboratory is the whole world declaims against this theory. But study for study's sake must be the delight of the selfish few. The man of ideas is a national asset upon whom his country has definite claims. It was a discovery of national importance to Germany when her chemists discovered how to make artificial indigo, for they killed India's great trade in the natural product.

There must, then, be no delay in the application of discoveries to their proper use. Procrastination may mean that a man who rightfully should be acclaimed a pioneer may become merely a follower. Great minds run frequently upon similar ideas. The memoirs of Darwin and Wallace on Natural Selection were read upon the same day before the Linnæan Society; Cros and Ducos de Hauron simultaneously communicated their process of indirect photography in colours. Graham Bell was only two hours ahead of Elisha Gray in patenting the telephone. Many other instances might be cited of simultaneity in discovery. In every field the searchers are busy, but there are many mines yet to be located.

For the art of war initiative and organisation are ever commanded. For the arts of peace there must be even greater alertness. The case remains as Pasteur put it: "Two opposing laws seem to be in contest. The one a law of blood and death, opening out each day new modes of destruction, forces nations to be always ready for battle. The other, a law of peace, work, and health, whose only aim is to deliver man from the calamities which beset him. The one seeks violent conquests, the other the relief of mankind. The one places a single life above all victories, the other sacrifices hundreds of thousands of lives to the ambition of a single individual. Which of these two laws will prevail? God only knows! But of this we may be sure: that science, in obeying the law of humanity, will always labour to enlarge the frontiers of life."

ERNEST A. BRYANT

Industries of Belgium and Switzerland. Course of the Rhine in Holland, Germany, and Switzerland. The Alps.

THE RHINE COUNTRIES

BELGIUM (11,500 sq. miles) is a small country, only half as large again as Wales. Geographically, it is a continuation of Northern France, the flat surface being represented by the Plain of Flanders in the north, while in the south the land rises to the forested Ardennes. The rivers are the sluggish Scheldt and its tributary the Lys, and the swift, picturesque Meuse, coming down from the plateau of Langres in a forested gorge through the Ardennes, before it crosses the plain to the delta of the Rhine, which it enters, as does the River Scheldt itself.

Though so small, Belgium is densely populated. In the plain the whole country is highly tilled, and looks like a vast market-garden, unbroken by wall or hedge. Farms and cottages are built on every spot which can be used without reducing the area under cultivation. New land is drained in the marshes or cleared in the forests to supply the needs of the growing population. Enormous quantities of vegetables are grown, as well as rye, oats, wheat, potatoes, and sugar-beet.

The industries are equally important. In Southern Belgium many manufactures flourish on the coalfield, which is continuous with that of Northern France. Iron is also abundant. Iron industries of all descriptions, including machinery, locomotives, and all requisites of modern engineering, are carried on exclusively in and around Charleroi, on the Sambre, and Liège, on the Meuse. The latter makes firearms of all descriptions, and may be called the Birmingham of Belgium. The woollen manufacture, partly due to the excellent wool of the Ardennes, has been important for centuries. The Leeds of Belgium is Verviers, east of Liège, where glass is also made. Brussels carpets are made at Tournai and elsewhere. In Northern Belgium the chief manufacturing city is Ghent, on the Lys, the Manchester of Belgium. It obtains raw cotton through Antwerp, on the Scheldt, the Belgian Liverpool, and the water of the Lys has remarkable bleaching properties. The linen manufacture has been important for centuries. Most towns make lace, especially Brussels, Ghent, and Mechlin. Brussels, the capital, on a tributary of the Scheldt, is a pleasing city, with modern suburbs. Its grand cathedral, town hall (Hôtel de Ville), and picturesque market-place, surrounded by fine old houses, recall the ancient splendours of the Flemish cities, which, in the Middle Ages, were the busiest manufacturing and trading centres of Northern Europe. Hardly one of the many Flemish cities, now decayed, but has fine specimens of the domestic and public architecture of the Middle Ages. Even Antwerp, with its great docks, enormous commerce, and all that makes up a modern port of the first rank, its broad streets and modern conveniences, its sugar-refining, distilling, shipbuilding, and other industries, preserves in its midst the mediæval city which attracts thousands of tourists annually. Ostend is the largest of Belgian watering-places, and an important packet station, especially for Dover.

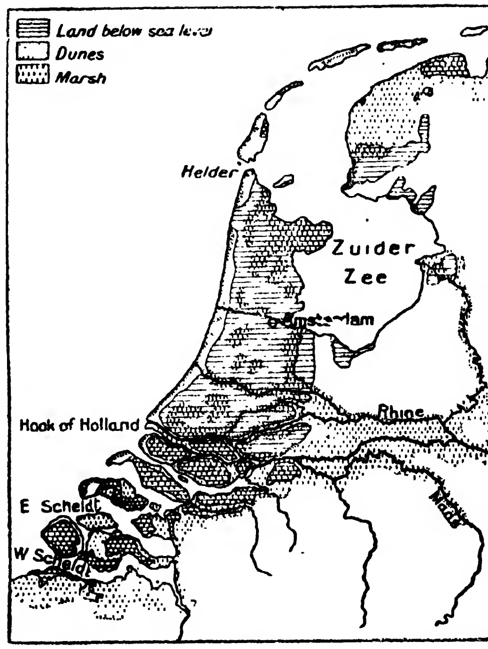
So far we have described regions with a geographical as well as a political individuality, but in Central Europe, as any map shows, the boundaries of the countries do not correspond with any geographical features. But here let us select geographical rather than merely political divisions, and begin by tracing the course of the Rhine from its delta on the North Sea to its cradle among the Alpine snows. This will bring us to the Alps, the greatest geographical feature of Europe, after which we can continue the description of the various other divisions.

Let us, in imagination, stand on a commanding peak in the Swiss Alps. We are on the gable roof of Europe, with the land falling away in all directions to the surrounding seas. Looking north on a clear day, we see, beyond the world of snow-peak and glacier in the immediate foreground, low, rounded hills, forested—if we saw them nearer—showing as a faint blue line on the distant horizon. These are not Alps, but part of the Central Highlands which stretch irregularly across Central Europe under various names, and with many breaks, at the base of the

Alps. Beyond this blue line of hills, if vision permitted, we should see the land gradually sinking to a vast plain, broken by outliers of the Central Highlands, and ending at last in the flat, marshy shores of the North and Baltic Seas. Across this plain we should trace the silver threads of many rivers, following the slope of the land northward to these seas. But of all these rivers, one, and only one, would be the child of the glacier streams sparkling in the Alpine valleys actually beneath our eyes. This river, the one link between the Alpine snows and the seas of Northern Europe, would be the Rhine.

Entering the Mouth of the Rhine. Much of Holland consists of the delta of the Rhine. The land bordering the North Sea is so low that the sea must be kept out by dykes, and so waterlogged that it must be drained by canals and pumped dry by windmills. Windmills and more windmills, canals, white houses, and green meadows are every traveller's first impressions of the Rhine and Holland. Of course, the sea has devoured great slices of such a coast, forming the shallow gulf of the Zuider Zee, and leaving a chain of sandy islands parallel to the coast. Across this flat region, which is largely made of sediment brought down by the river, the Rhine reaches the sea by many branches or distributaries, forming an intricate network of intersecting channels. We might, therefore, reach the main stream by many routes, from either the North or the Zuider Zee. The usual route is by the Hook of Holland and Rotterdam, on the Lek. At its delta the Rhine receives the Meuse, or Maas, from the hills of Lorraine, rising not far from the French Marne. It is hard to say whether the Belgian Scheldt from the Ardennes and the hills of Northern France, which enters what we may call the gulf of the Rhine, with innumerable islands and sandbanks, is or is not a tributary, but it must not be mistaken for a distributary. Flushing, on the island of Walcheren at its mouth, is where the pilot comes on board for the intricate navigation of the Scheldt to Antwerp, the port of the Scheldt.

Holland, or the Netherlands. Holland (12,600 sq. miles) is an almost treeless, alluvial land, destitute of minerals or building stone, but fertile where it can be drained. The climate does not differ much from our own, but is rather wetter. Cereals, hops, and sugar-beet are grown. The polders, or reclaimed meadows, pasture many dairy cattle, and much butter and cheese are exported. In some respects, therefore, it recalls Denmark. The Dutch are great gardeners, famous for their bulbs. Whole fields of them may be seen in flower outside some towns in spring. There are many industries, the raw materials being cheaply brought by water. The chief manufacturing centres—Breda, Tilburg, and Maastricht—are in the south. Rotterdam, the port of the North Sea, and Amsterdam, the port of the Zuider Zee, both manufacture the colonial produce brought to their wharves from the Dutch East Indies. Amsterdam cuts diamonds for all Europe. Many coast towns trade in butter and cheese, and, of course, engage in fishing. The capital, S'Gravenhage, or the Hague, is on the coast. Inland, a little to the north, is the university town of Leyden. The most important inland town is Utrecht, from which the lower part of Holland can be flooded in case of invasion.



THE DUTCH LOWLANDS

The Lower German Rhine. Crossing the German frontier, we find ourselves on the threshold of a busy industrial region. The valley of the Ruhr, the river which enters on the east bank where the great river port of Duisburg is built, has a large coalfield, which feeds the textile manufactures of Barmen-Elberfield, and the iron town of Essen, where the famous Krupp guns are made. It also sends coal by water to Krefeld, west of the Rhine, with silk manufactures. To the south is Aachen, or Aix-la-Chapelle, a woollen and cotton town, on a coalfield. Düsseldorf and Köln, or Cologne, the latter with the finest cathedral in the world, are accessible to ocean steamers, and their trade is enormous. So far both banks have been flat and uninteresting, though the regions on both sides are fertile and prosperous.

The Rhine Gorge. At Bonn, above Cologne, we enter the famous gorge cut by the Rhine through the northern part of the Central Highlands, between the Eifel and the Hunsrück on the west, and the Westerwald and Taunus on the east. Mile after mile we sail between mountain walls, each crag crowned by a ruined castle, and the lower slopes terraced for vineyards. At Coblenz, another great river port, the Moselle, from the Vosges, comes in on the west bank in a forested gorge between the Eifel and the Hunsrück. In its basin is the great fortress of Metz, the Saar coalfield with many manufactures, the independent Grand Duchy of Luxemburg,

and the old Roman town of Trier. Nearly opposite the Moselle confluence, on the other bank, comes in the Lahn, flowing in a similar forested gorge between the Westerwald and the Taunus. The Rhine gorge continues to Bingen, where we emerge into undulating country, and soon reach Mainz, at the confluence of the Main. If we could follow up this noble tributary it would take us by the banking city of Frankfurt, the university town of Würzburg, and the picturesque scenery of the Central Highlands, far into the heart of the Franconian Jura. We should certainly want to visit Nürnberg, on a tributary, the finest mediæval city remaining in Europe, and now a busy manufacturing town.

The Plain of the Middle Rhine. But we must follow the main stream across a richly cultivated plain, 20 or 30 miles wide, between the distant wooded Vosges on the west and the still more picturesque Odenwald and Black Forest on the east. At the busy port of Mannheim a glimpse up the Neckar makes us long to visit Heidelberg, on a lofty crag in its forested gorge. The Neckar is formed by many mountain streams, coming down in lovely valleys from the Swabian Jura, which separate the Neckar from the Danube. The chief town in its basin is Stuttgart, the capital of Würtemberg. The main stream of the Rhine continues across a land of cornfields, orchards, and vineyards. Karlsruhe, the capital of Baden, is connected with the Rhine by canal and has large engineering works ; Strassburg, with a fine cathedral, is the port for Mülhausen and other cotton towns of the Vosges. Freiburg lies at the entrance of a lovely valley leading into the heart of the Black Forest. We now approach Basel, or Bâle, the frontier town of Switzerland, a great centre of trade and railway traffic, about 750 miles from the mouth and 250 miles from the source of the Rhine.

The Rhine in Switzerland. The direction of the river valley now changes, narrowing between the Black Forest on the north and the Jura on the south. Above this it flows in a gorge between the Swiss and Swabian Jura, leading to Lake Constance. Swift tributaries, green with glacier sediment, rush down from the snowy Alps, now seen in the distance. The largest is the Aar, which rises among the highest peaks of the Bernese Alps, flows through Lakes Brienz and Thun, past Bern, the capital, and then northwards between the Alps and Jura, receiving, among many tributaries, the Reuss, from Lake Lucerne, and the Limmat, from Lake Zürich. At Schaffhausen are the Falls of the Rhine, where the river leaps madly down from the higher ground west of Lake Constance. We next reach its exit from that lake, and are but a few miles from the Danube, the great waterway of Western Europe. From a summit between the two we might possibly look down on waters flowing to the North and Black Seas respectively, so that here, in a sense, east and west, north and south, meet. After leaving Lake Constance, with its ring of towns, the valley leads us south, through scenery of increasing wildness. Swift rivers, leaping down 3,000 or 4,000 ft. in 20 or 30 miles, rush to the roaring torrent of the Rhine, whose valley narrows to a wild gorge. At last, 800 miles from the North Sea, our journey ends, at the source either of the Hither or of the Further Rhine, at a height of over 7,000 ft., among the grandest Alpine scenery.

The Alps. We have now reached the heart of the Alps, which stretch across Europe for 700 miles. We generally think of them as in Switzerland, but they extend west into France, east into Austria, north into Germany, and south into Italy.

To describe the scenery of the Alps in words is not easy. It varies greatly in different parts. In the limestone Alps of Austria the peaks and pinnacles are too steep for snow to lie, and they soar into the sky like fantastic obelisks of many-coloured rock. The familiar scenery of the Swiss Alps is something like this: Starting from our centre we climb on foot, or perhaps by rail or coach, up a smiling valley, between mountains clothed with forests of dark pine. Beside the road a swift torrent leaps from rock to rock in cascades of foam. Little villages of wood, with great overhanging roofs to carry the weight of the winter snow, are gay with vines, fruit-trees, and patches of maize. As we go on, the valley becomes more uphill, the mountain walls higher, the villages fewer, and the stream wilder. The bridges which cross it have canopies over them to prevent snow from breaking them down in winter. As we climb, the woods thin out, and their place is taken by steep meadows gay with flowers of every hue. The tinkle of the cow-bells and the little wooden cheese-houses tell us that we are among the high pastures, deserted in winter by man and beast.

An Alpine Glacier. Above the meadows appear walls of rock, and perhaps at the end of the valley a dazzling vision of snow-peak and glacier. The grass ceases, gay to the last with flowers. We are at the edge of the glacier, with its lines of moraine, rocks, and stones, which have fallen from the towering precipices above, clearly marked on its white surface. Most likely its end is hollowed into a glittering blue ice-cave, out of which gushes the stream we have been following. If we would reach the snowy summits, our way lies over the rough surface of the glacier, with its torn and twisted ice, split by deep chasms and crevasses of giddy depth and dazzling blue. The party is roped together, furnished with ice-axes, dark spectacles to dim the glare from the snow, and, above all, with good guides. Silently and cautiously, for a loud noise or a false step may start an avalanche of stones or snow and hurl all to destruction, the climbers make their way over glacier and snow-fields, or along a knife-edge of rock, to the summit, to behold a view no words can describe. They may descend on the Italian side, through similar scenery. The snow and ice will not come so low as on the Swiss side, and in the lower valleys chestnuts will replace pines, and mulberries, vines, figs and other fruit will speak of the Sunny South.

Valleys and Peaks of the Alps. To understand the geography of the Alps, let us first be clear about the famous St. Gotthard region, the cradle of many Alpine rivers. We reach the St. Gotthard Pass, the gate of this region, from Lucerne, by following the lake, and its feeder, the Reuss, up to a height of 7000 ft. A wonderfully engineered railway follows the valley to a height of 3800 ft. and then plunges into the bowels of the mountains in a tunnel 9¼ miles long, emerging at the head of the Ticino valley, which leads down to Lake Maggiore, Milan, and the plain of the Po. Only a few miles from the source of these two rivers are those of the Further Rhine, flowing east, and of the Rhone, flowing west, while those of the Aar, in the Bernese Oberland, are also near. Once clear as to these rivers, we can easily fix the geography of the rest of the Alps in our minds. The Rhone flows west in a great trough between the Bernese Oberland to the north and the Pennine Alps to the south. Zermatt, the needle-like Matterhorn (14,700 ft.), Monte Rosa (15,200 ft.), and other giant peaks are at the end of valleys opening to it from the south. From Martigny, where the Rhone turns north to Lake Geneva, we may visit the highest peak in the Alps, Mont Blanc, over 15,700 ft. South of the Mont Blanc group two rivers must be noted, the Dora Baltea, flowing south-east down to the Po, and the Isère, flowing south-west through the French Alps of Savoy and Dauphiné to the Rhone. Further south the Durance flows to the Rhone and the Dora Riparia to the Po.

The Aar has already been traced from the glaciers of the Finsteraarhorn (14,000 ft.), the highest of the Bernese Alps, to its confluence with the Rhine. Interlaken, between Lakes Brienz and Thun, commands a fine view of the Jungfrau, the queen of the Bernese Alps, and is the starting-point for their finest scenery. The courses of the Reuss and Rhine we know.

The Engadine and the Tyrol. East of the Rhine is the Vorarlberg district, and south the Engadine, perhaps the finest of all, with peaks 11,000 to 13,000 ft. high. The Inn flows through grand scenery to the Danube, between the Bavarian Alps and the Tyrol, with Innsbruck as its chief centre. From the Tyrol the Adige, or Etsch, flows south, near the Ortler group (12,800 ft.), the highest part of the Austrian Alps, the only one of the many rivers flowing south in long parallel valleys which does not enter the Po. Not far from the source of the Adige is the Gross Glockner (12,400 ft.).

Now both the scenery and direction of the valleys gradually change. The rivers no longer flow north and south, but east to the Danube, the largest being the Drave and Save. These eastern Alps form the Austrian provinces of Styria, Carinthia, and Carniola. From the northern end of the Austrian Alps spring the forested Carpathians, and from the southern the Dinaric or Dalmatian Alps, which border the eastern shores of the Adriatic. The Apennines of Italy are also an offshoot from the Alps, but with quite different scenery.

Notable Alpine passes are connected with the valleys mentioned. In the centre the St. Gotthard leads from the head of the Reuss valley to the head of the Ticino valley, thus giving a through route from the North Sea to the Adriatic. In the west the Mont Cenis, also followed by a railway, with a tunnel 7½ miles long through the core of the Alps, leads from the valley of the Arc, a tributary of the Isère, to that of the Dora Riparia, a tributary of the Po, and to Turin. The Brenner, in the east, leads from the Inn to the Adige. All these give through routes right across the Alps. The Simplon, with a tunnel 12¼ miles long, leads from the middle of the upper Rhone valley to the valley of the Toce and Lake Maggiore. Many famous passes, not accessible by rail, lead from one valley to another, but these need not be mentioned.

Switzerland. Switzerland (16,000 sq. miles) is a union of many independent cantons which grew up on both slopes of the Central Alps, round the lakes which fill many of the lower valleys, and on the plateau at their northern base. The Federal capital is Bern, on the Aar. Except on the plateau, the larger towns have become important because they command good routes across the Alps. Zürich, Luzern (Lucerne), Bern, Lausanne, and Geneva are examples. On the plateau the climate is that of Central Europe, with hot summers and cold winters. In the Alpine valleys the winter varies in severity with elevation. Winter snow covers the summer pastures, blocks many of the passes, and renders the streets of the higher villages impassable.

Why Switzerland is Prosperous. Switzerland is a brilliant example of what can be done by utilising the national resources, whatever they are. A land of uninhabitable mountains, with hardly any lowlands suited for agriculture, with no coal to feed manufactures, and producing hardly any raw material, it would seem to have small hope of prosperity, yet it is one of the richest countries in Europe. Mountaineers are generally resourceful and energetic, and the Swiss are no exception. They make the most of agriculture on the plateau, their manufactures are flourishing, their dairy industries world-famous, and they have brought to perfection what they call the *Fremden-industrie*, or trade in tourists.

The Tourist Industry. Switzerland discovered this industry and makes a fortune by it. Everything is done to develop it. Railways are carried everywhere, even up nearly perpendicular cliffs. Well-equipped hotels are built actually at the snow-line. Summer brings its tens of thousands of tourists, who enrich the army of caterers, cooks, waiters, porters, railway servants, and mountain guides who follow in their train. The favourite centres are the Engadine, where Davos is a sanatorium for consumptives; Zermatt, in the Pennine Alps; Interlaken, in the Bernese Oberland: Chamonix, for Mont Blanc, Vevey, and many other towns round the Lake of Geneva; and Luzern and smaller towns round that lake for the fine scenery about the St. Gotthard.

Swiss Agriculture. Agriculture is confined to the plateau and the lower valleys, where rye, oats, and potatoes are the chief crops. The summer is hot enough, especially on Lake Geneva, to ripen the vine and maize, and in the valleys of the southern slopes the mulberry and olive are also cultivated. Not enough food is grown for the population, and food-stuffs are largely imported.

The Dairy Industry. With the rich pastures of the Upper Alps, dairy farming was bound to be important. Many Swiss cheeses are famous, and the manufacture of condensed milk is a specially Swiss industry. The manufacture of chocolate, for which Switzerland has become world-famous, also consumes large quantities of milk. Notice how the character of a country affects even the way in which it pays to use milk. Other pastoral countries, Ireland, Denmark, Holland, make butter their staple, but they are maritime. Switzerland is in the heart of Europe, and transport is difficult and costly. Cheese, condensed milk, and chocolate, carefully packed, are highly portable, and do not spoil by keeping. Hence their selection. Let us never forget to look for geographical explanations of the nature of a country's trade.

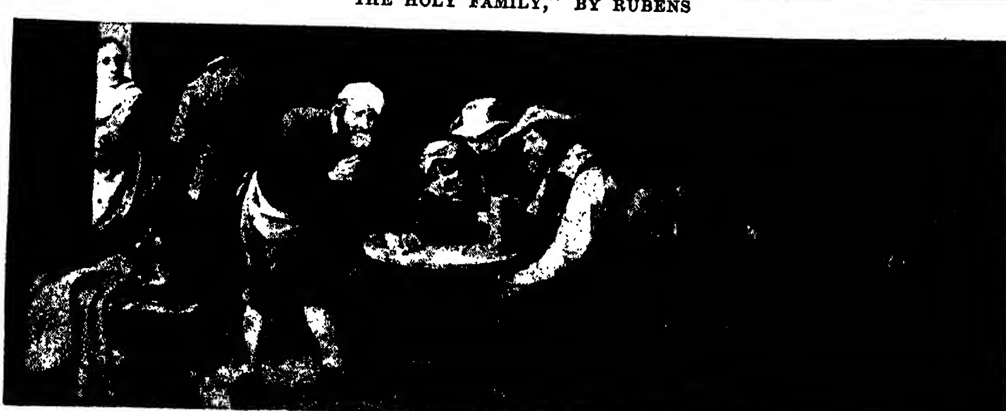
PICTORIAL MAP OF THE BASIN OF THE RHINE AND ITS RELATION TO THE NEIGHBOURING COUNTRIES

Manufactures. The manufactures are important, partly because the people are shrewd, industrious, and well educated, but also because there is an inexhaustible supply of cheap motive power. This is furnished by the irresistible force of the rivers rushing down from the Alps. Always important, water-power has become invaluable with the development of electricity as a motive power. The electrical industries are steadily growing in importance all over Switzerland.

The mountain railways are driven by electricity; and the nearer a town or hotel is to the snow-line, the more certain it is to be lighted by electricity. Textiles are manufactured in the busy towns of the plateau, silk at Zürich and Basel (Bâle), and cotton round Zürich and St. Gallen. Textile and electrical machinery is made at Zürich, the industrial capital of Switzerland, and locomotives at Winterthur. Geneva, the commercial centre of the west, gives its name to the watches and clocks made in the valleys of the Jura, in the canton of Neuchâtel, north of the lake of that name. Lausanne, magnificently situated on the north of Lake Geneva, is also a busy town, which has developed a "girls' school industry," if we may so call it, which draws its pupils from all over the Continent, and largely from England.

A. J. and F. D. HERBERTSON

"THE HOLY FAMILY," BY RUBENS



"INTERIOR OF A TAVERN," BY TENIERS

Renaissance Architecture and Sculpture outside Italy. Painting in Flanders and Holland. The Van Eycks. Rubens and Rembrandt.

THE ART OF NORTHERN EUROPE

Just as the Gothic style, born in the North, found the Italians reluctant to accept its tenets, so Renaissance architecture could only slowly force itself upon the Northern nations. In France and in Germany the new forms made their appearance comparatively late in the sixteenth century, and to a great extent lost their original purity through combination with Gothic motifs. The church of St. Eustache (A.D. 1532) in Paris illustrates the blending of the two styles, and such French private buildings as the castles of Chenonceau and Chambord show the picturesque combination of Renaissance motifs with Gothic turrets and slanting roofs.

One of the most graceful structures of the Renaissance in France is the famous winding staircase at Blois, which one critic has tried to prove to be designed by Leonardo da Vinci. The Louvre, the Luxembourg, the Panthéon, and the Dome des Invalides in Paris are notable examples of the French Renaissance. In Germany the castle of Heidelberg (A.D. 1545) is a remarkable instance of the blending of Classic decoration with Gothic sentiment. But in both countries the new style did not achieve complete victory before the seventeenth century, when its severe beauty had given way to the flamboyancy of the Baroque.

In England, the introduction of the Renaissance style is due to Italians, such as Torrigiano, the designer of Henry VII.'s tomb in Westminster Abbey, John of Padua, Giovanni da Majano, and Rovezzano.

The Elizabethan style, "an attempt on the part of the English to translate Italian ideas into their own vernacular," was chiefly employed for richly decorated private mansions and dwellings, of which we need only mention Longford Castle, built by John Thorpe; Knole, Kirby, and Penshurst. In the Jacobean period the Renaissance character became more pronounced, especially in the use of columns and entablatures. Holland House and Hatfield House may be quoted as notable examples. But Elizabethan and Jacobean buildings on the whole only form a transition from the Gothic to the pure Renaissance style, which appeared with Inigo Jones in the seventeenth century. This master's great buildings, such as the Banqueting Hall, Whitehall, and the Duke of Devonshire's villa at Chiswick, prove him a student and follower of Palladio. Inigo Jones was followed by Sir Christopher Wren, the builder of St. Paul's and several other beautiful churches. Wren died in 1723.

The progress of sculpture in Northern Europe cannot be followed as easily as in Italy, for in spite of the colossal output of artistic work in France, Germany, and the Netherlands there is a lack of brilliant individualities which stand forth as landmarks of the progressive stages of development. Local schools there were in vast numbers, and throughout these countries the same tendency is to be noted; but few, indeed, are the men whose names have been handed down through the ages as creators of masterpieces. Love of carefully studied detail, clear rendering of facial expression, close adherence to Nature, and delight in rendering the various textures are the chief characteristics of Northern Renaissance sculpture, which could never rival the triumphs of Italy, partly owing to the lack of classic examples, partly to the absence of the suitable material—the marble of which the Italians had an abundant supply at hand.

During the fifteenth century the art of wood-carving reached an extraordinary degree of perfection in Germany. The tendency of the carved wood statues and altars with many figures in high relief was distinctly pictorial, especially in the restless arrangement of the draperies; and painting and gilding were frequently resorted to to enhance the effect. Nuremberg at that time became the chief centre of German arts and crafts. It is almost essential to visit this quaint, old-world city to form an adequate idea of the art of this period, for it harbours the chief works of such masters as Veit Stoss, the wood-carver; Adam Krafft, the stone-

sculptor; and Peter Vischer, the bronze-worker, the author of the famous figure of King Arthur in the Hofkirche at Innsbruck.

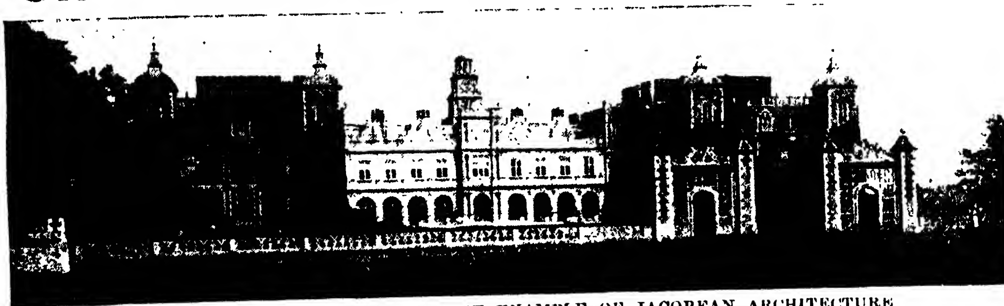
In France the chief works of sculpture produced between the Gothic period and the triumph of the Italian influence of the masters summoned by Francis I. to Fontainebleau are to be found among the monumental tombs at Dijon, Amiens, Rouen, St. Denis, and Bourges. Then Primaticcio and Rosso started the Italianising school of Fontainebleau, which produced sculptors like Jean Goujon and Germain Pilon. The naïve realism of the earlier sculptors had now given way to an elegant and sometimes mannered style, the chief aim of which was decorative effect. The reliefs of the Fontaine des Innocents, at the Louvre, in Paris, represent Goujon at his best, while Pilon's "Three Graces," likewise at the Louvre, illustrate this master's exaggerated elegance. What little indigenous style there was in English sculpture was stifled by Torrigiano, Benedetto da Rovezzano, and other Italians called to England in Tudor days.

The rise of pictorial art in the North coincides with the invention of oil as a medium for painting by the brothers Jan and Hubert Van Eyck, at the end of the seventeenth century. And, curiously enough, Flemish painting, at its very beginning, appears at a stage of development which Italy has only reached by slow and gradual steps. The Van Eycks are great masters, not only by comparison with those that went before, but even if measured by those that followed them. We have already seen how the conditions imposed by the Gothic architectural system limited the painter's activity to small panel pictures, so that his attention was fixed on the elaboration of minute detail, instead of monumental massing of line of form, and on soulful expression instead of stateliness of pose.

THE BRONZE STATUE OF KING ARTHUR
By Peter Vischer, in the Hofkirche at Innsbruck

Oil Painting in Flanders. The new school arose in Flanders—the Belgium of today—which was then one of the chief commercial and industrial centres of the world. The brilliant pageants of the Flemish cities, with their constant coming and going of wealthy traders from every part of the world, must have been a powerful stimulant to the local painters.

STATELY HOMES OF THREE COUNTRIES



HATFIELD HOUSE, A MAGNIFICENT EXAMPLE OF JACOBEAN ARCHITECTURE

THE LUXEMBOURG PALACE, PARIS, BUILT UNDER THE INFLUENCE OF THE RENAISSANCE

THE OLD CASTLE OF HEIDELBERG, A MONUMENT OF EARLY GERMAN ARCHITECTURE

The Van Eycks. Hubert Van Eyck was born about A.D. 1366, and worked principally at Bruges and Ghent. The subject matter and symbolism of his paintings are still quite mediæval, but the actual incidents, costumes and types; architecture and landscape, are lovingly and faithfully copied from the scenes which he had daily before his eyes, and set down with painstaking precision, which was only surpassed in minuteness by the work of his brother Jan. The "Adoration of the Lamb" is their chief work. Rogier van der Weyden, born in A.D. 1400, was a little less literal in his transcripts of nature, and more emotional in expression. Hans Memlinc, a Bruges painter of German origin, born about 1430, is the most lovable painter of a school which too frequently delighted in the realistic representation of scenes of tortures and other horrors. In him the realistic tendency of the school finds expression in the wonderful rendering of landscape and accessories, but he was an artist full of tender feeling and poetry, with a rare sense of feminine purity and innocent grace. Gerard David, who was born about 20 years later and worked at Bruges at the end of the century, was much influenced by Memlinc, and is distinguished by a glowing sense of colour and beautiful line. Quentin Matsys, born 1460, practised portraiture and genre, besides religious art, and marks a decided advance in expressive modelling. With Mabuse, who died in 1532, and even more with his contemporary, Raphael's pupil, Bernard van Orley, the Italian influence begins to filter through the local tradition, and in the case of the latter is to be detected in a more ample sense of design and a departure from the severe exactitude of the earlier masters. But what had been the result, in Italy, of centuries of slow development, could not be transplanted in its mature form to foreign soil, and became mere mannerism with the later Flemings, until a new era of superb artistry dawned with the advent of the great Rubens.

Rubens. Rubens (A.D. 1577-1640), too, had drunk at the same source of Italian art, and his early work in particular evinces his love of Venetian colour, but he brought into his painting a strong, virile and altogether personal temperament that could never have been content with mannered imitation. A colourist of tremendous power, Rubens excelled above all in the painting of flesh, in which he stands unrivalled to this day. One may be repelled by the coarse, fleshy type of his women, but the mastery with which he expressed with bold, sweeping strokes of luminous paint the roundness of form. the texture of the skin, and the very blood coursing under the skin, irresistibly compels one's admiration. The passionate movement, the vigour and verve of his work, seem to exclude the possibility of a deliberately calculated design, and yet the noble disposition of his figures, the effective massing of light and shade are as "scientific" as the movement and sensuous colour are instinctive. Rubens was the most worldly of all painters, yet he could treat a religious subject with a very reverent spirit. He was equally great in portraiture, in genre, in landscape, and in animal painting. But it should be remembered that in accordance with the custom of the period, he had a horde of assistants working under him, and many of the inferior pictures that pass under his name owe to him merely their conception, while the execution is entirely due to his pupils.

Van Dyck. Much the same remark applies to the greatest of his pupils, Van Dyck (A.D. 1599-1641), who, as Court painter to Charles I., exercised so potent an influence on English art that he may rightly be considered the real founder of the great English school of portraiture. Indeed, many of the paintings turned out from his studio at Blackfriars during his English period are the work of his numerous assistants, save for the first sketch and the finishing touches. Van Dyck, too, studied for some years in Italy, where, like his master, Rubens, he fell under the spell of the Venetians. An accomplished courtier and man of the world, he became the favourite of society in his native country, as in Genoa and in England. His pictures are a perfect mirror of the English aristocracy of his day, reflecting their taste and distinction and effeminate elegance. As a colourist, he was more subtle and refined, if less vigorous, than Rubens.

THE CHILDREN OF CHARLES I., BY VAN DYCK

The coarser side of Rubens's art attracted Jacob Jordaens, whose lack of refinement is scarcely atoned for by his great technical skill and good humour. Franz Snyders (A.D. 1579-1657) was a brilliant animal painter, whilst Jan Fyt and Jan Weenix excelled in still life, generally of dead game. Melchior Hondekoeter devoted himself almost exclusively to the bird life of the farmyard. All these masters were great colourists, and stand supreme, each in the narrow range he imposed on his art.

Growing Popularity of Art. The earliest Dutch painters, among whom Dierick Bouts and Lucas van Leyden are the most

THE DUTCH MASTERS OF PORTRAITURE

"THE NIGHT WATCH," BY REMBRANDT

"SYNDICS OF CLOTH MERCHANTS," BY REMBRANDT

A BANQUET OF OFFICERS," BY FRANZ HALS

prominent, were almost completely dominated by the genius of the Van Eycks and the other early Flemings. In fact, in their early stages, the two schools can scarcely be considered separately. Then came the Reformation and the War of Independence, which resulted, in 1648, in the final shaking off of the Spanish yoke. The long period of warfare and bloodshed was not favourable to extensive art production, but when Protestant Holland issued victorious, a great period of art commenced—of art led into new channels, since Protestantism looked askance at religious painting, and preferred bare, white-washed walls in the churches to an imagery of glowing colour. On the other hand, a demand for art arose in the civic community. The well-to-do citizens enlisted art for the adornment of their living rooms, and the subjects favoured were no longer, as may well be imagined, flagellations and crucifixions, and images of the Virgin and saints, but portraits, landscapes, genre scenes depicting the daily life of the burghers and peasants, and, for the guild halls and other official buildings, large portrait groups of prominent burghers.

Pictures in the Dutch Home. Of idealism and ideology, there is little or nothing in Dutch art which is entirely based on love of nature and on the keen appreciation of the value of pigment. The rich quality of the paint, the subtlety with which the play of light and shade on objects and textures is observed—these were the chief points that appealed to the Dutchmen. These little genre scenes—interiors of burghers' houses, with ladies before a mirror, or occupied with books or musical instruments; or tavern scenes depicting the life of the humbler classes—are never of anecdotal or literary character; they are just glimpses of real life stated in terms of ornamental craftsmanship. Of this nature are the precious gemlike pieces of Terburg, Vermeer van Deft, Metzu, Jan Steen, Mieris, Gerard Dow, and, in Flanders, of the Teniers, who had more in common with the Dutch "small masters" than with the Flemings.

'ST. MATTHEW,' BY REMBRANDT
The Louvre Paris

Frans Hals. But the seventeenth century small masters were preceded by a few men who must rank among the very giants in the realm of painting. Rembrandt is one, and by no means the least brilliant, of the great triple constellation that stands out from the firmament of art, the compeer of Velasquez and Titian. Before him, Frans Hals (A.D. 1584-1666) had achieved the greatest triumphs in bold, daring portrait painting. For sheer bravura and dashing brushwork and brilliant characterisation, Hals has probably never been equalled, and his large "Doelen" groups at Haarlem are an inexhaustible source of delight to all who can appreciate masterly brushwork. Then, Van der Helst (A.D. 1613-1670) may be taken as the most capable of the numerous serious portrait painters who recorded with faultless conscientiousness in a somewhat tight manner the features of civic dignitaries and their buxom housewives.

Rembrandt the Revealer. But with Rembrandt (A.D. 1606-1669), all hardness, one might almost say all linear design, was abandoned, and everything that the artist's eye could see, or his brain conceive, expressed in terms of soft lights and shadows and golden, liquid half-shadows. Everything is given plastic form through the play of light on the surfaces which are seen through the surrounding atmosphere. In his golden illumination and forced contrasts, Rembrandt is, perhaps, not always strictly true to nature, but he has the power to make us feel that, if such conditions of light were possible, faces and objects would appear just as he has set them down [see "The Night Watch," reproduced on page 1617]. Rembrandt is the antithesis to the Italians of the Renaissance, who were ever striving for beauty. With him character is everything, but the mastery of his brush and his sympathetic insight into the very soul of his sitters give beauty even to subjects repellent in themselves. Apart from his paintings, Rembrandt's etchings alone would entitle him to one of the most exalted positions among the world's great artists. P. G. KONODY

The Three Orders of Levers in the Body. How the Erect Position is Maintained. Walking, Running, and Jumping.

MOTION AND LOCOMOTION

Motion in itself is no more a proof of life in a man than in a steam-engine; it is the method by which it is produced in man that differentiates him from a machine. Motion and locomotion are not the same. Motion is movement only, but locomotion is movement from one place to another; in walking we get both.

A great deal of motion takes place in the body apart from locomotion, although, in fact, the body as a whole does not change its place.

For motion or locomotion four structures at least are necessary as regards the mechanism. Something to be moved—the bones; a place where they move—the joints; machinery that moves them—the muscles; and a force that controls the machinery—the nerves; and all movements involving these structures take place according to mechanical laws. These, then, we will briefly consider.

A System of Levers. The principle with which we are most concerned is that of *leverage*, or movement by means of levers. A lever is simply a bar that lifts (French *lever*—to lift), which may be either straight or crooked, and made of any rigid substance, such as wood, iron, or bone. All our bones are used as levers or bars. [See page 1025.]

Now, as a rule, we can do so much more work with levers than we can do without them that Archimedes, who discovered their use, said that if he had a lever long enough, and a fulcrum to rest it on, he could move the world.

The parts in a lever are three in number. They are the *fulcrum* (F), or the fixed point on which the lever moves, which in the body is invariably a joint; the power (P), or the force that moves the lever; and the weight (W), or the object that is moved.

Orders of Levers. The orders of levers vary according to their relative position, thus:

WFP is the first order—that is, when the fulcrum is in the middle. PWF is the second order—that is, when the weight is in the middle. WPF is the third order—that is, when the power is in the middle.

Levers of the Body. Now, all three orders of levers are used in the body [71], although the third is undoubtedly the favourite, for a reason that will be evident.

Tapping the foot on the ground, raising the head off the chest, and straightening the arm are examples of the first order. Thus:

W.	F.	P.
foot	ankle-joint	muscles of calf
head	joint with spine	muscles of spine
hand	elbow-joint	triceps muscle

Standing on tiptoe is an instance of the second order.

P.	W.	F.
calf-muscle	body	toes resting on ground and acting as a joint.

Bending the arm, closing the jaw, are examples of the third order, thus:

W.	P.	F.
hand	biceps	elbow-joint
jaw	jaw muscles	jaw joint

Respecting this third order, observe that the power, or the muscle, is attached between the fulcrum in the joint at one end and the weight to be lifted at the other.

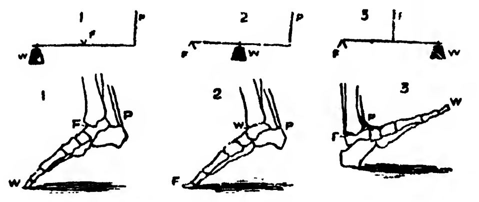
The nearer the muscle is attached to the weight to be lifted the more it has to be contracted to lift the weight, whereas the nearer it is attached to the fulcrum the less it has to contract, but greater force is needed. For instance, consider the attachment of the muscles of the arm and leg. You will have noticed how all the body-levers have the fulcrum close to the power at the end of the bar. Thus, the elbow-joint is close to the point of the elbow behind, and the ankle is close to the heel; and you will also have noticed in the same way that in every case the muscles are attached as near to the fulcrum, or joint, as possible. Those that lift the arm are fixed just below the shoulder; those that lift the forearm are fixed just in front of the elbow; those that move the thigh just below the hip; and those that move the leg just below the knee.

Why a Muscle is Attached near the Fulcrum. The object is to give the greatest movement of the limb with the least contraction of the muscles. If you take two bits of firewood a foot long, and join them together at one end with a tack, open them at right angles, and tie a string from one end to the other, it will be 17 in. long. To bring the ends of the two pieces together by pulling on the string, you must use up all the 17 in.; but if you tie one end of the string close in front of the joint in the way our muscles are fixed, you will find that, though you have to pull harder to bring the pieces of wood together, you only use up about 1 in. in length of the string to move the ends of the firewood 17 in. [72].

By this contrivance, therefore, the slight contraction of the muscles can move the limbs a great distance. When you kick a football, your foot goes through a great space, but the muscle that moves it only contracts an inch or two.

Shoulder and Hip Contrasted. Some special joints in the body call for a brief consideration. Let us first contrast the shoulder and the hip. The shoulder is not a fixed joint, but can be moved backwards and forwards to a certain extent. It is supported behind by

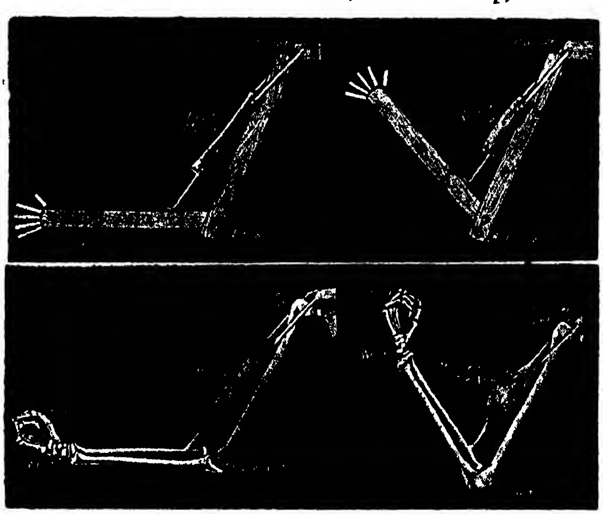
the shoulder-blade, and in front by the collar-bone. This latter bone has a double curve; all shocks received at the shoulder, therefore, as in falls, or in striking, etc., are broken by the spring allowed in the shoulder itself, and by the spring in the collar-bone. If the shock, however, is very violent, the jar breaks the collar-bone about the middle. The shoulder is not a universal joint—that is, it cannot move in all directions, but it practically does so, as it is not stopped by the pressure of flesh against flesh in any direction, excepting inwards, when the arm is brought against th side. In an upward direction, however, we cannot raise the arm above the level of the shoulder, because the end of the collar-bone and the arm-bone then come together. If we wish to raise the arm higher, the shoulder itself, being movable, is tilted up, The joint has muscles on all four sides, which pull the arm upwards, downwards, inwards, and outwards.



71. THE THREE ORDERS OF LEVERS
1. Tapping the ground with the foot. 2. Raising the body on the toes. 3. Raising the toes from the ground.

Now the hip, though a universal or ball-and-socket joint, differs from this in nearly every particular. While the chief peculiarity of the shoulder is its elasticity and its free mobility, the hip is noted for its great strength and firmness, and limited power of movement.

The hip-joint is perfectly rigid, and never moves itself, the socket being part of the strong, bony pelvis. Although the thigh can move in every direction to a slight extent, it cannot move very far in any. Its forward movement, which is the greatest, is checked by the meeting of all the fleshy part of the thigh with the abdomen. Its backward movement beyond a straight line with the pelvis is checked by a strong fibrous band that stretches across the front of the joint. The movement inwards is checked by the other leg, and outwards by other bands, and by a strong cord that fastens the ball of the head of the femur to the bottom of the socket of the hip-bone of the pelvis. It is surrounded with powerful muscles, except on the inner side, where they are weak



72. MODEL AND DIAGRAM SHOWING HOW THE MUSCLE RAISES THE ARM

How we Stand Upright. Some other joints may be considered as we look at the phenomenon of the erect position in man. At first sight it appears that nothing could be more natural than the erect attitude. It is only when we look at the means by which it is attained that we see what a feat it is to stand upright. The attitude itself is peculiar to man, and is not natural even to the anthropoid apes.

Let us consider how this position is maintained. We will begin at the foundation and go upwards. This tall column, 6 ft. high, more or less, called the body, is balanced on the front of the feet (about 3 in. square), and upon the two heels (about 2 in. square). The toes are in front of the body, and, if the latter tends to fall forwards, press firmly against the ground to prevent it; the heels, too, are behind to prevent the body from falling backwards. If the body tends to fall sideways, the foot on the side towards which it leans, pressing the ground, restores the balance.

Having the two feet, then, firmly planted, the two legs come next. They are hinged at the knee, and would naturally fold up backwards if not forcibly kept straight. The muscle that does this is the powerful extensor of the leg, which, passing down in front of the thigh, crosses the front of the knee, is fixed into the knee-cap, and continued down to the top of the shin, or the tibia, where it ends, and so braces the leg straight. The leg cannot fold forwards because of the crucial ligament in the knee-joint, neither can it twist to one side or the other.

Necessity for Standing Erect. Now we have the two legs upright, how are we to balance the body on the two balls of the hip-joints without falling over? For it would naturally appear that we should topple forward or backwards unless incessantly braced up by muscles before and behind. Here, however, we come across a beautiful contrivance for saving the dreadful fatigue a muscle would undergo by such a continued effort. There is no danger of the hip-joint folding up forwards in the erect position, as the body is heavier behind the joints, and the strain is rather to prevent the body from falling backwards.

From the front on each side of the pelvis, therefore, passing across the front of each joint, and

fixed just below in the front of each femur, is a band of fibres, not muscle, so strong that nothing can break or stretch it. If we stand quite erect the whole strain is thrown off the muscles on to these powerful bands, which, when put to the full stretch, just allow the legs and body to extend in a straight line, but not more; so that the body by this means is balanced on the legs without fatigue. Those who have not learned to stand thus, soon tire.

The spine, being firmly fixed into the hip-bones, is first bent forward, to throw the weight of the heaviest part to the front, and then, as the weight gets lighter, it bends backwards between the shoulders, and forwards again in the neck, there being no joint that can double up between the hip and the neck. At the neck a good deal of the strain of keeping the head erect is taken off by an elastic ligament like a strong indiarubber band, which passes from the occiput to the spine, and so keeps the head erect without appreciable effort.

Horses which have a long neck, and a heavy head to hold up at the end of it, have a similar band of immense thickness running from the head along under the mane to the shoulder.

The human body, then, tends to fall backwards below, and forwards above; that is, there is less support for it behind at the heels than forwards at the toes; so the ankle, knee, and hip would all fold backwards if they could, while the head would drop forwards on to the chest when the muscles are relaxed, as in sleep.

Arrangement to Preserve the Brain from Shock. Before leaving this subject the contrivances to preserve the brain from shock are worth noticing. Passing from above downwards, we notice *first* that the brain itself is saved from all jars by not touching the base of the skull, but floating on a sort of water-bed. In the *second* place the spinal column is a double curve, forming a double spring, thus breaking shocks; and, *thirdly*, the pad of cartilage inserted between each pair of vertebræ breaks all jars travelling up the bones. *Fourthly*, at the fourth pair the base of the spine is wedged into the pelvic arch. In this case the keystone is inserted between the two side bones, upside down, so that the broadest part of the sacrum looks downward and forwards, and the narrow end points backwards and upwards. It is thus slung between the bones in such a way, like a carriage hung on "C" springs, that every jar upwards or pressure downwards tends to separate the keystone from the arch instead of jamming the bones together, and so reduce the shock.

The *fifth* contrivance is that the head of the femur is at right angles to the shaft, which alone reduces the force of shock one half.

The *sixth* is the slant of the femur to the middle line; and the *seventh* is at the knee, where we have between the bones two strong pads of cartilage to prevent all jarring.

The *eighth* is the keystone which forms the instep of the foot. In this case it is set in the usual way, with the broad end uppermost, and the narrow end below resting on a *stout* band of fibres, which breaks all jar.

The *ninth* and last is in the foot, where the hinder pier of the arch comes straight down to the ground, and is formed of one bone, called the heel; but the front pier slopes very gradually, like a spring, and is composed of twenty-four bones. Thus, we get in the foot-arch solidity behind and elasticity in front [6, page 101].

Walking. The movement of the body from place to place is the result of combined action of many muscles. In the act of walking the muscles of the arm should be entirely relaxed, as they are not required in any way, and the arms should be left to hang naturally.

In starting to walk, say, with the right leg, the muscles of the calf raise the heel from the ground, while the muscles in front of the abdomen pull the body a little forward, still further raising the right heel. When the body is inclined forward to a certain extent, it would fall over were it not for the next act, which consists in allowing the left leg to move forwards to support it. This is done partly by a pendulum-like swing, and partly by a forward pull of the muscles in front of the thigh.

The left leg is now in front of the body, and the balance is restored; but the right leg has not ceased to act yet. It continues to push the body still further forwards while the muscles in front of the trunk still pull it over, until it is in advance of the left leg, thus raising the right leg off the ground and allowing it to swing forwards in its turn. Walking thus depends on pushing upwards with the leg and pulling forwards with the front of the trunk. As the body is supported alternately on each leg, it is inclined a little from side to side, so as to throw the weight fully on it, and prevent falling over sideways. Thus the body in walking is continually rising and falling, and swaying slightly from side and side.

Jumping, Running, and Hopping. Jumping consists in a spring off the ground, caused by the sudden contraction of both calves forcing the toes so violently against the ground that the body is jerked into the air.

Running is a series of short jumps with each leg alternately, so that both feet are constantly off the ground at the same time. The body is inclined still more forward than in walking.

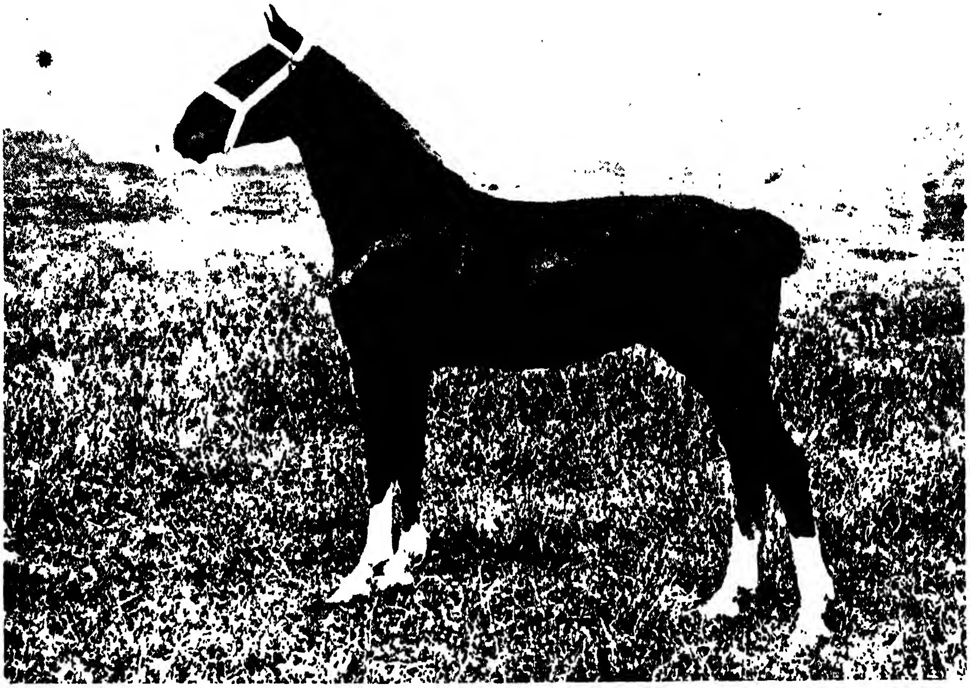
Hopping consists in a jumping on one leg, caused by the most violent contraction of the muscles of the calf of which they are capable.

We may, in conclusion, note that movement is by no means a necessary sign of strength. Babies move all their muscles a great deal, and often without much reason, because their minds have not yet got much control to quiet their movements, but the older and stronger a person gets, the less he moves excepting when he wants to do so, because he has all his muscles under control. To keep constantly moving, therefore, does not show that we are strong, but may indicate that the brain power is weak.

In the locomotor, as in all other systems of the body, there are control centres that prevent unnecessary or excessive action, and tend to promote a steady, healthy condition.

A. T. SCHOFIELD

ENGLISH HORSES FOR LIGHT & HEAVY WORK



A HACKNEY HORSE

A SHIRE HORSE

The photographs of these prize-winners are reproduced by courtesy of Messrs. Chivers & Sons

Famous Breeds. Rations for Horses at Rest and at Work. The Farm Horse. Breeding and Breaking-in. The Age and the Teeth.

THE MANAGEMENT OF HORSES

Our Breeds of Horses—The Shire. This magnificent breed was formerly known as the Old English cart horse, and was practically made in the counties of Lincoln, Cambridge, Derby, and Notts, but it gradually extended to adjoining counties, and subsequently to every part of England. Since the establishment of the Shire Horse Society the Shire has become one of the most popular horses with farmers and landowners. It is chiefly black or dark brown, with white marks on the face and feet; bays are occasionally seen, but other colours are rare. It often reaches 17 hands in height, and in a good specimen the girth is from 7 ft. 9 in. to 8 ft. 6 in. While highly symmetrical in form, it may be described as "much in little." In build the Shire is square and massive, possessing a big chest, a short back, powerful shoulders and loin, long quarters, deep, well-sprung ribs, muscular thighs, legs short below the knee, heavily clothed with fine silky hair or feather, and short pasterns. The head is long and fine, but broad between the eyes; the neck arched, and the feet large and wide; the body lines are highly symmetrical. The weight of good specimens exceeds 2000 lb.

The Shire is a fast and active walker, and is largely bred by farmers, many of whom keep pedigree mares for the purpose, which they employ in their teams on the land. The produce is chiefly sold for heavy draught purposes to brewers, carriers, and the like. The Shire is perhaps the most powerful horse in the world. It is docile and intelligent, and is believed to be descended from the old English war horse, an animal of much smaller size. Great prices are often obtained for prize-taking stock, and, chiefly owing to exhibitions, the breeding of this animal has become an important industry. Pedigree stallions owned by wealthy landowners and farmers or hired by societies travel through most parts of England.

The Clydesdale. The Clydesdale is the draught horse of Scotland, chiefly used for the heavy work on the farm and the drawing of heavy loads in the great centres of population. In colour it is usually dark brown or black with white markings; not quite so large as the Shire, it reaches a height of 16 to 16½ hands. While symmetrical in form, it is massive and powerful, possessing a gentle disposition and great activity for its size. The head is well formed, the neck arched and strong, the shoulders oblique, the back short and hollow, the chest wide and deep, the ribs round and well sprung, the quarters strong, the thighs powerful, the legs muscular and straight, and the bone, like the knee, flat, the pasterns sloping, and the feet broad and strong. The Clydesdale is a fast and free walker, and is on one side descended from stock imported from France.

The Suffolk. This variety, which is chiefly confined to East Anglia, is, on account of its heavy body and short limbs, known as the Suffolk Punch. Its colour is almost invariably chestnut, although varying in shade. It is active, courageous, and strong, walking and trotting easily; averaging about 16 hands in height, it sometimes reaches 16·2, and weighs from 1850 up to 2200 lb. The Suffolk possesses a neat head, a short neck, powerful shoulders, a well-rounded body or barrel, which is massive as compared with the legs which support it. The forearms are short and stout, the thigh muscular, but the legs are light in comparison with those of the Shire and Clydesdale, and carry no long hair. The pasterns are short and strong, and the feet smaller than those of other heavy breeds.

The Thoroughbred. The thoroughbred, or race horse, is the produce of our ancient native breed crossed with the Arab and other horses of Eastern origin. It is a somewhat nervous creature, exhibiting great speed, spirit, courage, and endurance. In build it is graceful, with fine skin, silken hair, and plenty of sinew. Under the management of a Royal Commission money is annually awarded to selected sires, which are distributed throughout the country for the use of farmers and others at low fees. The object is the production of hunters, carriage, and other saleable horses, which the thoroughbred is well adapted to produce when crossed on selected mares. The head, although wide in the nostrils and the forehead, is fine, especially at the muzzle. The neck is long and slender, the shoulders long and flat, the loins short, the quarters muscular, the legs long and flat, but short from the knee to the pastern, which is elastic, the forearm and thigh long, the chest high, and the constitution exceptional. In colour the thoroughbred is usually bay, brown, or chestnut, other colours being comparatively rare. In height it reaches up to 17 hands; according to one of our best authorities, Sir Walter Gilbey, the height of the racehorse was 14 hands in 1700, 14·3 in 1800, and 15·25 in 1900.

The Cleveland Bay. This is an improving breed, which is bred in the Cleveland and adjacent parts of Yorkshire and Durham. It is employed on the farm for light draught work, for the saddle, and even for carriage work, the mares being specially adapted for the production of carriage-horses when crossed with the thoroughbred. In height it reaches from 16 to 16·2 hands, and its colour is the richest bay of any of our native breeds. The mane and tail are black, and the legs dark. The head is not well

formed, but the neck and shoulders are well set, the latter sloping and powerful. The chest is deep, the back short, the barrel round, the loins powerful, the quarters long and especially well formed, and the legs clean.

The Coach Horse. Chiefly bred in Yorkshire, this variety has, like the Cleveland bay, to which it is closely allied, improved in form and quality owing to the establishment of a society. The mares are largely employed for the breeding of coach horses and hunters. In colour the coach horse is usually brown or bay with dark legs; the head is neat, and the crest arched, the shoulders sloping, the loins powerful, the quarters symmetrical and strong, the legs flat, and the feet good. The coach horse has excellent action, and stands from 16 to 16·3 hands in height.

The Hackney. This is, perhaps, the most striking and popular of the light horses of British breed. Its stepping, high action, and speed in harness and saddle combine showiness with usefulness. The Hackney is bred is almost all colours, although the chestnuts are the most popular. It stands over 15 hands, 15·3 being its outside height. The breed is the result of crossing—it has Arabian blood in its veins - and of selection. Its neck is of moderate length, shoulders deep and sloping, ribs nicely rounded, back short, forearms short and strong, and hindquarters broad and muscular. The tail is placed high, and is invariably docked. The Hackney is altogether smart, spirited, and symmetrical. When moving, its action should be from the shoulder and not from the knee. The Hackney Horse Society, which has vigorously promoted the extension of this breed, the home of which may be regarded as Norfolk and Yorkshire, was established in 1883, and holds its annual show at Islington.

The Polo Pony. The polo pony is a wonderful production of the art of the trainer. Although the variety has scarcely become a definite breed, really good animals are remarkable for their speed, courage, stamina, and intelligence. The polo should not be under 14 hands. It may be of any colour, while its formation should be such as will enable it to accomplish its work most perfectly. Many crosses have been made in breeding, especially with the Barb and the thoroughbred, the former mated with polo mares being preferred by some authorities, who regard the Hackney as unsuitable for this purpose. There is now a Polo Pony Society.

New Forest, Exmoor, Welsh, and Shetland Ponies. The New Forest pony, which may be of any colour, although usually black or brown, stands from 12 to 14 hands. It is a plucky, hardy breed, and may be regarded as the survival of the fittest, for large numbers of ponies have died in the Forest in the past, where they are frequently turned out for the whole winter. Useful animals may be obtained at the Lyndhurst and other annual fairs, but many are somewhat difficult to break. Standing about 12 hands in height, the Exmoor pony is usually bay in colour, thickly built, strong, quick, short-legged, and has plenty of stamina.

The Welsh pony, standing from 12 to 13 hands, is a thrifty animal, varying in colour, duns being frequent, and possessing sound, flat legs and good feet.

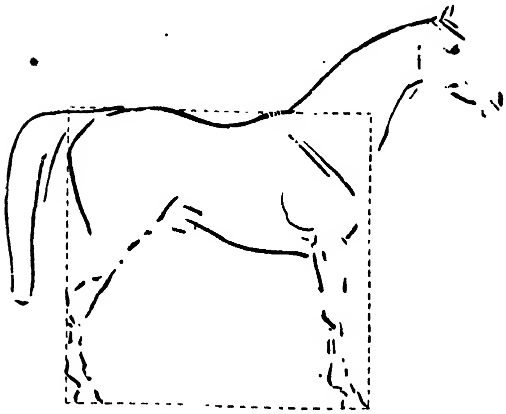
The Shetland is the smallest of British breeds, and stands from 7½ to 10 hands high. It is short in the neck and back, gentle in disposition, furnished with muscular quarters and sound feet.

Methods of Feeding. Although horses are kept by all sorts and conditions of men, feeding is generally practised upon very similar lines. The most popular foods in the British Isles are hay and oats. There are, however, wide differences in the quality of these two foods as employed respectively by the costermonger and the huntsman. Good oats should be used, and they should be hard and thin skinned. Hay should be the finest early cut mixture, containing a sufficiency of clover herbage, and it should be fragrant and sweet. Oats are preferably crushed for aged horses and horses with bad teeth, while the hay should be chaffed, the allowance never exceeding 12 lb. daily unless the circumstances are exceptional. Two or three pounds of sweet oats or wheat straw-chaff may be added to a day's grain ration in accordance with the size of the animal. Whether crushed maize, barley, malt, or beans, bran, middlings, or linseed meal or cake, or an occasional mangel or carrot, be added to the ration, depends upon circumstances, to which reference will presently be made.

Maintenance Ration. Food is supplied to the horse, first, for the purpose of maintenance, and next, for the purpose of providing for the energy expended in labour. A horse at perfect rest practically requires a maintenance ration only—that is, sufficient food to maintain the heat of the body and the wear and tear of tissue without loss of weight. According to Zuntz, a horse weighing 1000 lb. can be maintained on a daily ration of hay and grain providing 6·4 lb. of digestible nutritious matter, of which not more than 3 lb. in the total ration should consist of crude fibre. Grandeau experimented with three horses averaging 852 lb. in weight, which he maintained upon 17·6 lb. of hay daily, of which, on the average, 6 lb. were digested by each, this being the equivalent of 6¾ lb. for a horse weighing 1000 lb. Wolff found that a horse at rest weighing 1100 lb. required 7¼ lb. of digestible matter excluding fibre, this, too, being equal to 6¾ lb. of fibre-free food for a horse weighing 1000 lb.

It should be pointed out that horses digest coarse fodder less perfectly than cattle and other ruminants, so that, although they require less for maintenance purposes, they need about the same quantity for this reason. Jordan accepts a daily ration of 6·6 lb. of digestible nutritious matter for a resting horse weighing 1000 lb., and suggests, among other formulæ, 10 lb. of hay and 5 lb. of oats, or 12 lb. of hay and 3½ lb. of bran, or 3 lb. of oats, or 2½ lb. of cracked maize.

Feeding the Working Horse. We have seen that a horse of given weight can be maintained when at rest on some 6½ lb. of digestible matter—that is, on that portion of the dry material of food which is nutritious and digestible, this being regarded as the maintenance ration. The feeder next requires to know what additional quantity of food



A WELL-FORMED HORSE
His height is equal to his length. Note the dotted lines forming a square. The pictures on this page are from Captain Gomme's "Hints on Horses," published by Mr. John Murray.

should be provided for the accomplishment of a given amount of work by a horse of given weight. When we speak of food in this connection we mean the digestible portion of the additional ration provided. An addition to a ration having been made, it is important to understand, although the fact can only be approximate, what it means when translated into energy; nor must we forget that energy is expended as well when the animal moves itself as when it is moving its load. Let us again refer to the work of Zuntz, who found that about a third of the total energy provided by food could be utilised in the form of labour. This experimenter points out that a horse weighing 1000 lb. when walking a mile at the rate of from two to three miles an hour would, to quote from Jordan on the "Feeding of Animals," "expend a total energy of 473 foot-tons, 44·4 per cent., or 201 foot-tons, of which belong to the effort of walking over and above the energy needed for mere maintenance." Thus, although we can only regard the results as approximate, in walking and drawing a load 20 miles, the labour performed would be equivalent to the lifting of 9300 tons one foot.

In feeding a horse it should be remembered that speed tells as well as weight. Thus, a fast draught horse expends more energy in accomplishing the same amount of work than a slow draught horse, and consequently it requires more food, although the additional food supplied for the accomplishment of additional work should be rather in the form of grain than of hay, a large quantity of which is not adapted to the limited capacity of the digestive organs of the horse. Many authorities regard 12 lb. of hay as a limit. This being so, it follows that the ration of a horse should be concentrated, well balanced, and mixed with chaff, and supplied more frequently than in the case of ruminants.

The Food for the Fastest. A hackney or nag horse employed for any fast work requires more food, weight for weight, than a draught horse, more energy being expended in a given time, so that the cost of horse labour increases with the speed with which it is performed. In practice, however, horses kept for fast work are kept at rest during more hours daily than draught horses; consequently a balance is struck, and the total food consumed is not materially increased, and time is given to the animal to recuperate. Farmers, as a rule, prefer fast horses on the land, but if such animals are worked the full complement of hours daily, they require more food than slower horses, and wear out more quickly. In the table which follows on the next page are some suggested rations for heavy horses.

The difference between the German standard and English practice, as shown by the rations given by farmers, and suggested by Fleming, is remarkable, but in practice there is just as much difference in the weight of the rations supplied by farmers themselves. In many cases meadow, mixed, or clover hay is freely supplied, apart from the chaff used in mixing with the corn, while the oats provided on one farm may reach three bushels per week and on another only two bushels.

Proportions of Food. A French observer of wide experience finds by direct experiment that a draught horse in ordinary work requires 12 lb. of digestible dry matter per 1000 lb. live weight, the proportion of fatty matter increasing with size. On the basis of the argument of Zuntz, if we assume that 6½ lb. of dry digestible matter are required for the purposes of maintenance of a horse of 1000 lb., some 14 lb. of additional digestible dry matter would be required were such a horse engaged in walking with a draught of 1000 lb. on a level road for 20 miles. We

ACTION OF A HACKNEY HORSE WHEN TROTTING

have seen that the ratio between the albuminoids of food on the one hand, and the fats and carbohydrates on the other, varies. Experience suggests that with increased work the albuminoids should be increased, and consequently the ratio reduced. It is for this reason that in heavy work beans are constantly added to oats, especially where such work is fast; but, inasmuch as

RATIONS FOR HEAVY HORSES.
(Per Cent.)

	Dry matter.	Albuminoids.	Fat	Carbohydrates.	Ratio.
Horse at heavy work, weighing 1,000 lb. (Wolff)	25·5	2·8	0·80	13·4	1–5·5
Do. moderate work .	22·5	1·8	0·60	11·2	1–7
Heavy horse at regular work (Fleming). Oats, 18 lb.; beans, 2 lb.; hay, 18 lb.; straw-chaff, 2 lb.	32·8	3·1	1·05	16·5	1–5·9
Farmer's summer ration (McConnell). Oats, 10½ lb.; beans 2 lb.; chaff, 2 lb.; grass, 100 lb.	34·8	3·4	0·9	18·6	1–6
German standard for a horse weighing 1,000 lb., in moderate work	—	—	11·4	—	—
Do. in average work	—	-	13·6	—	--
Do. in heavy work..	—	—	16·6	—	--

the carbohydrates (sugar, starch, gum) and fats are chiefly employed in the animal economy in supplying the necessary energy, they may be provided in larger proportion for slow work, with the result that the ratio will be wider.

The employment of maize in the ration of a horse depends largely upon circumstances. It is inadequate for fast work; it may be used with judgment for medium or slow work. Maize, however, is not so safe a food nor so well balanced as the oat, although, when the price of both foods is moderate, there is a wide difference in the cost of the feeding matter supplied. Let us suppose that maize costs 25s. per quarter of 480 lb., and oats 20s. per quarter of 320 lb.—this weight providing a good sample. According to the following figures, 100 lb. of maize will provide 73·8 lb. of digestible dry matter, while 100 lb. of oats would provide only 57 lb.; the cost of the former would be 5s. 2¼d., and of the latter 6s. 3d., or, in other words, the nutritious matter of the maize would cost ·85d. per lb., and of the oats 1·3d. per lb. [See table.]

Food.	Bushel. lb.	Price.	Digestible and Nutritious. Albuminoids.	Carbohydrates	Fat.	Digestible lb. per cent.	Cost of 100 lb.	Cost per lb. Digestible. Pence.
Maize ..	60	3/1½	8·4	60·6	4·8	73·8	5/2¼	0·85
Oats (good)..	40	2/6	9·0	43·3	4·7	57·0	6/3	1·3

The third table is a suggested ration, to include maize, for a horse weighing 1000 lb. in moderate work, the figures being approximate. With the same weight of maize and hay, the oats might be replaced with 5 lb. of barley or 6 lb. of bran, or 6 lb. of desiccated grains; but a change should be gradual, the complete alternative never being immediately effected. Horses fed on such a ration should, when subjected to severe work, receive an increase in the quantity of oats, in addition to 2 lb. of beans daily. In all cases the horses of the farm benefit by an occasional warm bran mash, which it is customary to supply on the Saturday night, or an occasional handful of linseed meal, or of crushed linseed cake, the albuminoid ration being maintained at about 1-5. The meaning of this ration it is now necessary to explain.

Food.	Dry Org'nl.	Albuminoids.	Carbohydrates.	Fat.
12 lb. Hay ..	9·7	·70	5·15	·15
6 lb. Oats ..	5·0	·53	2·50	·25
5 lb. Maize ..	4·2	·42	2·90	·25
2 lb. Straw-chaff	1·6	·02	—	·70
	20·5	1·67	10·55	1·35 = 13·57

Albuminoid Ratio. The term means the proportion between the albuminoid and the non-albuminoid digestible matter of food. Nitrogen is a leading element in all albuminoids; it is not present in either fats or carbohydrates. Were we, however, to describe the two sets of constituents as nitrogenous and non-nitrogenous, we might mislead, inasmuch as a portion only of the nitrogenous constituents of food is utilised in the animal economy.

The Purchase of Horses. In buying a horse an expert may be deceived. The amateur is, therefore, advised to employ professional help, and thus to minimise his risk. Those accustomed to horses, however they may trust their own judgment in other respects, will do well to employ a veterinarian to examine a proposed purchase for health and soundness. A horse should first be seen at home in the stable, and overhauled in every particular. The object should be to ascertain if there is vice, unsoundness in body or limb, and that the age given is correct, as shown by the teeth. Whether led at the walk or the trot, driven or ridden, it is well that a disinterested and capable groom or coachman should be employed unless the purchaser can trust himself. For his first examination the animal should be led to a level spot, where his teeth, eyes, wind, hearing, mane, withers, and limbs may be examined in turn. Something may be learned from the way he stands; hence he should be looked over from both front and back. He should stand firmly and four-square, not resting a weak limb or tender foot. He should be walked and trotted, ridden or in harness, and, in the case of a draught horse, be placed in a loaded cart, which he should be required to draw and to back. Again, he should be tested for shying, kicking, and even bolting, as well as for any other vices which may be suspected.

A sound horse should be able to see and hear clearly, and be afraid of nothing he sees or hears. On return to the stable, he should not exhibit timidity, or temper, or weakness of wind or limb either immediately or after a lapse of an hour. For such troubles or diseases as spavin, ringbone, splints, sandcrack, navicular, fistula, poll-evil, and the like, as already suggested, an expert should be employed. In selling a horse a warranty should never be given,

either verbally or in writing, if there is a shadow of doubt on any point, for it includes faults of which the owner knows nothing. On the other hand, a buyer should endeavour to obtain a warranty for self-protection.

Horses for the Farm. The farm horse, being required for heavy draught work, as ploughing and rolling, drawing loads of manure to the fields and corn to the station of the merchant, requires great strength and endurance, as well as speed in walking. The object in breeding, therefore, is to obtain these qualifications. He must be of large size, well formed, the muscles being prominent where they are most needed, and the legs and feet absolutely sound and strong. Constitution demands plenty of room in the chest, which should be deep, broad, and long, well-arched ribs providing plenty of room for heart and lungs. Add docility and good temper, and we shall not be far wrong.

Horses for Breeding. In selecting stock for breeding, it is important that the stallion, or sire, should have a long, straight head, and broad forehead; short, wide, muscular loins; prominent, well-curved ribs; a belly proportionate to the size of the animal; fore legs whch are straight, squarely set when looked at from the front, and not too far under the chest. The hind legs should be equally square, well formed, straight, without tendency either to bowness or what is termed "cowhock." The feet should be well formed, sound, neither turned inward nor outward, and always firmly planted on the ground. There should be neither defect of eye nor ear, still less of breathing. In a word, it is imperative that for reproductive purposes both sire and dam should be in perfect health and vigour, and as nearly perfect in form and temper as possible. In many cases, mares are kept for field work and are also used for breeding purposes.

The Mare. The plan is a good one, but never should a weedy, unsound animal be employed as a dam. If a mare has a pedigree, which in large part means reliability of constitution, so much the better. She should be in good condition, and without any serious fault, and the younger the better, although in many cases mares are employed for breeding up to an advanced age. Both sire and dam should be in the full vigour of life. The mare comes into season from seven to ten days after foaling. The breeding mare may be worked nearly to the date of foaling, but she should obtain a rest of a few days under any circumstances. Parturition occurs about eleven months after service, the date of which should be kept, and, as the time closely approaches, it will be noticed that the udder begins to expand. The mare usually foals without assistance, whether on the pastures in sufficiently mild weather, or in the loose-box, where she should be subsequently kept for a few days prior to turning out with her offspring on a fine, warm day in a paddock.

A GROUP OF SHETLAND PONIES

After foaling the mare should receive a few bran mashes and an occasional mash of boiled roots, with crushed oats and sweet hay. The box should be specially cleaned, purified, and littered with clean straw before foaling. If green food be available, it should be gradually introduced, unless the animal has been receiving green rations beforehand. Until mare and foal have been hardened off to outside exposure, they should return to the loose-box at night; subsequently both will benefit by remaining altogether upon a dry, yet soft, turfed pasture, on which they may be fed from a movable crib or manger from day to day. The mare should be kept in condition as well for the benefit of the foal as for her early return to work, and the foal should be liberally fed from weaning onwards. Without good feeding, size is unattainable, especially on poor soil. In the rearing of

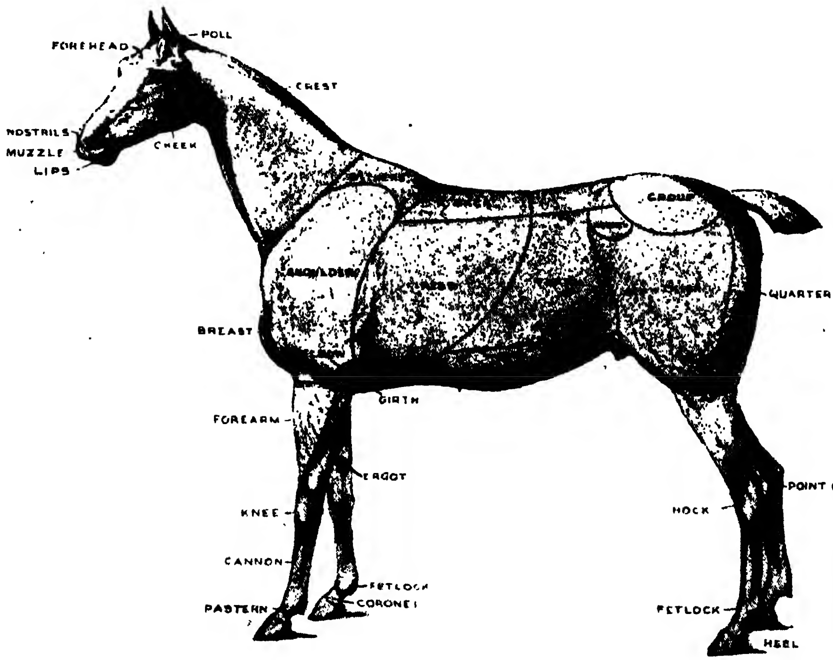
young horses, it is important that the best grass should be placed at their disposal, but it should be neither short nor wet, many foals being lost upon both, and on many parasites abound.

Weaning Foals. When the mare returns to work, the hours during which she should be employed should be gradually increased, but she should never work too long in the day before weaning, nor return to her foal while still warm, both practices being liable to cause diarrhœa, or scour, in the youngster. A strong foal may be weaned at the age of six months. If he feeds well, his ration of oats may then be increased, but the food supplied should always be of the best. Extra care should be taken with young stock in winter, and yet there should be no coddling. Colts may be turned into a well-sheltered, or covered yard, where they can lie dry, and where they are protected against biting winds and driving rains. The colt may be castrated at from 12 to 15 months.

Breaking. Farm colts and fillies are more easily broken than those of almost any other class. The breeder should make friends with his stock from birth. Thus breaking becomes extremely easy, and almost without any effort a young animal submits to the halter and subsequently to harness for the plough or the waggon. There should be no suspicion of harshness or cruelty in word or deed. When, by the gradual introduction of the halter, the bridle, plough chains, and other harness, the young animal is submissive, he may be placed in harness by the side of a steady old horse, and induced to assist in drawing a log of wood, then a bush harrow, made on the framework of a hurdle or an old gate. This will prepare the way for attachment to a chain harrow, and subsequently to the plough, the roller, the waggon, and the cart. At first the experiment may be a short one, gradually increasing until the colt becomes fit for a short day's work. He should be encouraged by word and act, and rewarded on his return to the stable. In this way a colt may be gradually brought into daily work at the age of two and a half years.

The Age of the Horse. The adult male possesses 40 teeth, and the female 36, the temporary teeth in each sex numbering 24. These teeth are succeeded by the permanent teeth, which begin to appear at from two to two and a quarter years from birth. Where horses mature early, and where they are accustomed to eat coarser food than usual, the permanent teeth sometimes appear earlier than is normal. The 12 front teeth, top and bottom, are known as incisors, while the molars number 24, of which only 12 are temporary. In the male, however, although they are occasionally found in the female at from eight to nine years, there are four canine, or corner, teeth. In the young animal the mouth is complete with the temporary teeth at two years, and with the permanent teeth at five years old. The corner teeth at this age are but shells, while the middle and central teeth are well developed. When a horse has reached eight years and is aged, the marks on his teeth have been worn away, and it is next to impossible to mistake him for an animal of younger years.

JAMES LONG



THE PARTS OF A HORSE

Sulphur and the Halogens. Iodine and Life. Platinum and its Absorption of Gases. Copper, Silver, Gold, and Mercury. The New Alchemy.

THE REMAINING ELEMENTS

Sulphur. Unlike oxygen, this element is a solid at ordinary temperatures. It has a yellow colour, is insoluble in water, has a lustre of its own quite distinct from metallic lustre, melts on heating, and assumes crystalline form under certain conditions, two distinct kinds of crystals being recognised, while under other conditions it is amorphous, and may even become elastic. Sulphur is thus a very conspicuous illustration of the chemical property which is called *allotropism*, or *allotropy*, and has already been discussed. Both as a liquid and as a gas sulphur exhibits similar properties. We have already noticed that, in the case of the gas, conditions of temperature determine whether the sulphur molecule has the formula S_6 or the more familiar formula S_2. This element is found in the native state in Sicily and in other volcanic regions, and a large proportion of the sulphur in commercial use is obtained from these native deposits. Iron pyrites also yields a certain proportion of commercial sulphur.

An Important Ingredient of Living Matter. This element is of very great interest from many points of view: it has for long been regarded as an absolutely essential constituent of living matter, ranking in this respect with carbon, oxygen, nitrogen, and hydrogen. Some experiments by Dr. Charlton Bastian, F.R.S., now in process of repetition by other observers, appear to show that sulphur may, however, not be essential as these four other elements are—that is to say, that certain very lowly forms of life may possibly survive without it. This uncertain exception apart, sulphur must certainly be regarded as a most important ingredient of living matter, and, therefore, of the food of all living things. It is taken up by the plant in the form of the compounds called sulphates, and is built up into various complex compounds that are of use to animals, which live either upon plants directly or upon other animals, which, in their turn, live upon plants.

Sulphur also has very marked uses, though with a comparatively small range, in medicine. Whether applied externally, as in the form of an ointment, or taken by the mouth, sulphur owes all its medicinal actions and virtues to its formation in the body of compounds, the essential constituent of which is its compound with oxygen (SO_2). This compound is really the anhydride of an acid, *sulphurous acid*, which has the formula H_2SO_3, and which is to be carefully distinguished from the more familiar *sulphuric acid*, which is more completely oxidised, and thus has the formula H_2SO_4. These are discussed later.

The Halogens. The derivation of this term has already been explained, and the four members of this very well defined group of elements have been named *fluorine, chlorine, bromine, iodine*. These are all chemically active in a high degree, and none of them is found free in nature.

Fluorine. *Fluorine* is found chiefly in the form of fluorides, such as calcium fluoride, often called fluor-spar (CaF_2), and cryolite, the double fluoride of sodium and aluminium. Minute traces of calcium fluoride occur in the teeth, but are possibly not to be looked upon as more than accidental; traces of this salt are also occasionally found in the bones. Less than thirty years have elapsed since this element was isolated by electrolysis. When obtained in elemental form it is found to be a gas with a faint greenish colour—though, perhaps, pure fluorine has scarcely any colour at all—and makes violent chemical attacks upon almost every known substance, oxygen and nitrogen, however, being conspicuous exceptions. Hence it is an exceedingly difficult element to keep in its elemental form. Indeed, there is no known material of which to make vessels that will not be susceptible to its attacks. The best substance appears to be an alloy of the two rare metals, platinum and iridium. By far the most important compound formed by this element is known as hydrofluoric acid, which has the formula HF. This acid exactly corresponds to the most important acids formed by the other halogens—namely, hydrochloric acid (HCl), hydrobromic acid (HBr), and hydriodic acid (HI). The great French chemist who first isolated the element, M. Moissan, and Sir James Dewar are noted for their researches in regard to the properties of fluorine, and to their discoveries there has been added the interesting demonstration that certain chemical actions can occur even at extremely low temperatures. Notable among these is the union of hydrogen and fluorine to form hydrofluoric acid. It had been supposed that at very low temperatures, such as that of liquid air, chemical action could scarcely occur, but it has now been shown that there yet remains for the chemist a hitherto unexplored region of vast importance, which Sir James Dewar calls *low-temperature chemistry*.

Chlorine. *Chlorine* is also a gas, with a decided yellow-green colour, to which it owes its name (Greek—*chloros*, green). It has a number of uses, and has to be obtained from its compounds in sea-water and elsewhere. The only method of its preparation that need be quoted is that which depends upon the interaction of hydrochloric acid and the dioxide of manganese.

What happens is that the oxygen of the latter turns out the chlorine from the hydrochloric acid, some of the chlorine combining with the manganese and some going free. The following equation represents the action:

$$MnO_2 + 4\ HCl = MnCl_2 + 2\ H_2O + Cl_2.$$

Like fluorine, though in less degree, this element is chemically very energetic, and in its undiluted state is scarcely less dangerous to work with. Pressure and cold readily convert it into a yellow liquid or solid. Also, like fluorine, it has great affinities for hydrogen, and will actually take this element—with which it forms hydrochloric acid (HCl)—not only from organic compounds which contain it, but also from its extremely powerful combination with oxygen to form water. Thus, while chlorine is soluble in water, it very readily decomposes the solvent, keeping the hydrogen and displacing the oxygen. This oxygen, at the moment of displacing, is *nascent*, and has the properties of any nascent element, as we showed when discussing peroxide of hydrogen. Hence, chlorine is, though so indirectly, one of the most powerful of all oxidising agents in virtue of its power of liberating nascent oxygen from water and other substances. This property of chlorine is chiefly used in order to bleach various materials, which it does by thus oxidising and altering the colouring matters that they may contain. The explanation we have given of the oxidising properties of chlorine will enable the reader to understand why the dry gas has no such properties. Chlorine is inimical to every form of life, and is thus probably the most certain and searching of all known disinfectants, though also, unfortunately, the most undiscriminating. This property also doubtless depends upon its oxidising action. Nevertheless, chlorine, when combined with other elements, has very different relations to living matter, for certain chlorides—especially sodium chloride, or common salt (NaCl)—are necessary constituents of the food of practically every living thing.

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Bromine. As we advance in the series of the halogens, we pass from bodies which are gaseous at ordinary temperatures to one which is liquid at those temperatures, and finally to one which is solid. *Bromine*, the third member of the series, is a liquid (with a deep red colour) that readily evaporates, producing a gas which has a disagreeable smell (Greek—*bromos*, a stink). In general, its properties closely resemble those of the previous members of the series. It occurs in nature mainly in the form of bromides, many of which are of importance in medicine, in photography, and for other purposes.

Iodine. *Iodine* is a dark crystalline solid at ordinary temperatures, but readily evaporates, forming a violet-coloured gas. It is much less soluble in water than its predecessors; the vapour is very irritant, and has a similar action on the lungs and air passages to that exerted by the other halogens. While chlorine is of great use in medicine, indirectly, in virtue of its extremely marked antiseptic properties, iodine is used in medicine directly, occasionally internally, and very frequently externally. It is still more valuable in the form of its salts, especially the iodides, such as the iodide of potassium (KI), which is obviously the potassium salt of hydriodic acid.

Iodine and Living Tissues. When iodine, in its elemental form, is brought into contact with living tissues it exercises very marked actions. These are best illustrated by a consideration of what happens when a not too strong solution of iodine is painted on the skin. Doubtless the element undergoes rapid combination with certain of the tissues of the skin. In one form or other, it is certainly capable of being absorbed, and of exerting marked actions upon tissues lying at a considerable depth beneath the surface of the skin—almost as much so as if elemental iodine had been applied directly to them. In the language of medicine, elemental iodine and some of its compounds are said to act as *alteratives*, the reason being that they seem to produce very marked changes in the behaviour of various tissues. These changes are often so profound and extensive as to be quite out of proportion, it would appear, to the relatively small amount of substance that produces them. Hence it seems probable that the action of such a substance as iodine may be comparable in some small measure to the behaviour of oxide of barium, which is used, as we recently saw, in the commercial process for the obtaining of oxygen.

Mysterious Power of Iodine. We have seen how chlorine acts as an oxidising agent, and it seems probable that iodine, whether in its elemental form or as an iodide, must have the power of transferring oxygen from place to place, or acting as a so-called oxygen carrier, being thus able, even in very small quantities, to do a very large amount of work, just like the oxide of barium, which helps itself to an extra supply of oxygen, disposes of it, and thus is able to repeat the process indefinitely. Of course, in the example we have quoted, the conditions of temperature and pressure are altered by an agency from without; but it is quite conceivable that there may be a similar automatic mechanism in the body which enables iodine to act as it does.

The further and final stage in the illustration of the sort of process we are describing is furnished by the *ferments*, that extraordinary group of substances the property of which is that, by their mere presence, and without undergoing any change in themselves, they are able to cause the most marked chemical changes in other substances with which they are in contact. We are far from supposing that the above sentences offer a chemical explanation of the properties of iodine, or of any other alterative substance; but it is, in effect, the explanation which is advanced by one of the very greatest students of the chemical interactions between such substances as iodine and the living body—Professor Binz, of Bonn. It was not necessary to refer to the method by which bromine may be obtained in its elemental form, since elemental bromine is of small utility, and since the process is essentially the same as that by which iodine

is prepared. It was in the substance called *kelp*, variously defined as seaweed, or the ash of the seaweed, that iodine was first discovered. The plant obtains it from the sea-water in which it lives, and obtains bromine in like manner.* When the ash is distilled with sulphuric acid and the now familiar dioxide of manganese, first the iodine comes away, and then the bromine.

Since the first edition of this work a simple and invaluable use has been found for iodine. This element is powerfully antiseptic, and yet *comparatively* harmless to the skin. The surgeons have found that the simple painting of the skin with a solution of iodine in alcohol completely sterilises it, so that a surgical operation can be freely performed. The action occurs at once. All the elaborate scrubbings and washings and dressings, needing two or three days for the best results, are now thus superseded, and the patient's skin can be safely prepared, at shorter notice and with no trouble or subsequent harm, by this simple method.

The Halogens and the Periodic Law. It is now hardly necessary to say that the whole series of halogens offers excellent confirmation of the periodic law of Mendeleeff, and that the chemical properties of these bodies, the conditions under which their compounds are formed, and their reactions generally, correspond in an extremely significant degree to the properties which might have been assumed for them by anyone who had nothing but the periodic law from which to argue. For instance, the atomic weight, the boiling point, the specific gravity, the temperature at which combination occurs with hydrogen, and a whole series of further properties, follow definite gradations in the case of these four elements.

It is not improbable that this group will afford the most valuable help to the chemist and the physicist in their most recent and most important enterprise, which is the attempt to infer, from what they know of the various elements, the details of the atomic structure or architecture of those elements, and the exact manner in which, for instance, the atom of chlorine differs from, yet resembles, the atom of fluorine, while the difference between the two must consist in some detail of structure which is perhaps repeated or doubled in order to get the further differences represented by the bromine atom, and lastly by the atom of iodine.

Peculiar Properties of Platinum. Platinum is a very rare and precious metallic element. Chemically, it may be grouped with another metal, *palladium*, and with certain others of very small importance in themselves, such as *osmium*, *rhodium*, *ruthenium*, *iridium*. These elements occur in nature uncombined and in the metallic state, usually in the form of tiny grains in the sands of certain rivers. Platinum is thus found in California and South America, Australia, and the Ural Mountains.

The processes by which these metals are obtained in any quantity in the pure state are extremely difficult and complicated. When at last metallic platinum is obtained in a form that can be manipulated, it is found to be a white, lustrous, silvery metal of a very great weight (its atomic weight is nearly 195), and having a number of very important physical properties. For instance, it is extremely difficult to fuse or melt, requiring the temperature produced by the immediate union of oxygen and hydrogen in the oxy-hydrogen blowpipe.

Readers of the course on PHYSICS will understand what is meant when we say that this rare metal has extreme tenacity, is very malleable, and very ductile. It does not oxidise even when heated in pure oxygen; strong mineral acids do not affect it, nor is it acted upon by moist air. For all these reasons, platinum is very extensively used in various chemical operations, especially when it is required to deal with powerfully corrosive liquids, such as sulphuric acid and hydrofluoric acid, or when any great heat is required. The metal can be cast and forged, and can also be welded; furthermore, it expands under the influence of heat only very slightly, so that when it is fused through glass, as in the ordinary incandescent electric lamp, alterations in temperature cause the platinum and the glass to expand or contract proportionately, so that the glass is not cracked by the expanding metal when the lamp is lit.

Absorption of Gases by Platinum. In a previous chapter we made some reference to the remarkable property possessed by some substances of absorbing gases within them. Charcoal is a conspicuous and familiar instance of a substance which has this power. It is to be remembered also that there is more than a merely physical absorption of the gas, since in the case of oxygen the result of this absorption is to increase its chemical activity. Hence it seems probable that the molecular arrangement of the gas is disturbed. Now, platinum, when finely divided and forming the black powder *platinum black*, has this property of condensing gases in it to an extraordinary degree, being able to absorb, for instance, some hundreds of times its own volume of oxygen.

Another form of platinum, called *spongy platinum*, and also the platinum black of which we have already spoken, are able to induce chemical actions, such, for instance, as the direct union of oxygen and hydrogen at ordinary temperatures—which is explicable if we accept the view that the condensation of such gases within their pores is more than a merely physical act, and implies a change in the molecular constitution of the gases, so that they become practically as chemically active as if they were *nascent*. Very probably, indeed, they *are* nascent, in the sense that a large number of their molecules are broken up, so that unpartnered atoms of oxygen and hydrogen are wandering about, being thus more ready to effect chemical combinations with foreign atoms than if they went about with each other in pairs, as they do in the molecules of these gases in ordinary conditions. The element osmium, first mentioned above as belonging to the platinum group, has lately been found invaluable for the formation of filaments that can be made luminous by an electric current.

The Last Group of Metals. Finally, we must discuss a very important group of metallic elements consisting of *copper, silver, gold,* and *mercury.* We may take these elements together, even although they do not exactly fall into a group in the table of the periodic law published by Mendeleeff in 1904. When we were discussing the atmosphere, we saw that the new group of gases discovered in the air by Lord Rayleigh and Sir William Ramsay—helium (already known elsewhere), neon, argon, krypton, xenon—*must* now be regarded as the zero group of the elements. Not one of these gases has any combining power at all, so far as can be made out. Group one of the elements has already been partly discussed. Its members have combining power, each atom of any typical one of them having, so to speak, one arm, and being therefore called monovalent. The members of this group, in the order of their atomic weight, are hydrogen, lithium, sodium, potassium, copper, rubidium, silver, cæsium, and gold, and the reader will notice that the lighter members of the group have already been considered. Ignoring the very unimportant elements, rubidium and cæsium, we are therefore left with copper, silver, and gold. According to Mendeleeff, mercury, which has so many remarkable peculiarities, belongs not really to this group at all, but to group two. We are bound to note this fact; yet we may conveniently adhere to the long-established arrangement, and discuss mercury together with the other three elements we have named.

What Makes Copper Valuable. All these four elements are found in the elemental state in nature. But the first of them, copper, more commonly occurs in combination either with oxygen or with sulphur. It is very readily obtained from its oxide by the now familiar employment of carbon, in the form of charcoal or coke, which takes the oxygen to itself and leaves metallic copper behind. Or copper may be displaced from the familiar salt known as copper sulphate ($CuSO_4$) by means of iron, which forms sulphate of iron ($FeSO_4$), the copper being precipitated; and a third method of obtaining metallic copper consists in an interaction between the sulphide and the oxide. The sulphur and oxygen of these respectively combine to form the gas sulphurous anhydride, or sulphur dioxide (SO_2), metallic copper being left behind.

This extremely valuable metal has a distinctive colour, an atomic weight of rather more than 63, but a very small degree of hardness. It is very malleable, tenacious, and ductile [see PHYSICS], is fusible—that is to say, melts—at a red heat, and is an excellent conductor both of heat and electricity. In this last respect, as in the others, it resembles silver and gold, but, being much cheaper than either of these metals, it is naturally preferred to them as a material for wires to convey electric currents.

Bronze. Amidst all these valuable physical properties of copper it is to be noted that there is one—viz., its relative softness—which interferes with its utility for many purposes. But when copper forms an alloy with tin there is obtained the substance called bronze, which is very much harder. Bronze has been known since very early times, and the student of what we are now learning to call pre-history speaks, as we have already seen, of the Bronze Age, which succeeded the Stone Age, and marked a great advance in civilisation, largely dependent upon the newly acquired knowledge of manipulating bronze, and was in its own turn succeeded by the Iron Age. Thus, this element, copper, has its own special interest for the philosophic student of the means by which man gradually emerged from primitive savagery. Here we may also note that in recent years it has been discovered that the addition of a small quantity of phosphorus to bronze, producing the alloy called *phosphor bronze,* greatly increases its hardness, and gives it a new value as a material for cog-wheels and other parts of machines where great hardness it desirable.

It was the opinion of the late Lord Avebury that the use of copper was not introduced into Europe at all until it had first been discovered somewhere in the East that a much more valuable substance could be produced by the addition of a small quantity of tin to it—that is to say, by the making of the alloy called bronze. The alloys of copper now in use are very numerous—about 70 per cent. of copper and 30 per cent. of zinc forming brass—while there are various modifications of bronze besides phosphor bronze, the aluminium bronzes and German or nickel silver, the alloy of copper and zinc, to which reference has been made.

Copper and the Human Body. Minute traces of this element are not infrequently found in the human body, yet it is certainly not to be regarded as a desirable constituent of the body, but rather as a more or less undesirable foreign substance which has gained access to it by means of the food. Salts of this metal are often used in order to make more vivid the green colour of vegetables, such as bottled peas, and the question arises whether the use of copper for this purpose is justifiable.

There is good reason to believe that if the quantity employed is very small—though quite large enough for the purpose—it has no injurious action upon the body, copper being exceedingly difficult to absorb, so that even if moderate quantities are frequently swallowed no harm is done. So far as acute poisoning from copper is concerned, the risks are also very much less than is commonly supposed; and the smallness of the risk of chronic copper poisoning may be estimated from the fact that there is no proof of this having occurred even amongst workmen engaged in the manufacture of *verdigris,* which is the acetate of copper.

Silver. This precious and familiar element occurs, as we have already stated, in its elemental form in nature, and is also frequently found in combination with sulphur, the sulphide of silver being known as *silver glance.* It also is found in union with mercury in various parts of the world. We have purposely avoided the use of the word "combination," which would beg

the question whether this body is really to be regarded as a compound or as a mixture. Its composition varies, and we know that the composition of a true compound is absolutely invariable. But, on the other hand, this *amalgam*, as it is called, is crystalline, and the relation of the elements in it must probably be regarded as more than mere mixture.

Why Silver is Valuable. The appearance of silver and its capacity for taking a high lustre are familiar; like copper, it is very ductile, malleable, and a good conductor of heat and electricity. Also like copper—and the same applies to gold—it is not oxidised by the air, no matter whether moisture be present or not. Copper, however, can be oxidised at a red heat, but silver only at a much higher temperature and under great pressure, while gold cannot be made to unite with oxygen directly at all.

The marked stability of these metals led them to be called in former days the "noble metals." They vary in their nobility, however, as we have already seen, and even at ordinary temperatures silver loses its lustre and its purity in the presence of compounds of sulphur, such as the gas called sulphuretted hydrogen (H_2S), or the gas we have already mentioned, sulphur dioxide. (SO_2). This change is due to a formation of a thin film of the black sulphide of silver.

A curious illustration of this property of silver is furnished by the consequences not infrequently observed when considerable doses of sulphur are being given medicinally to people who wear silver ornaments, such as bangles, next to the skin. In such cases the patient is sometimes puzzled to know why the bangle cannot be kept clean; its blackening is due to the fact that some of the sulphur given to the patient is passed through the skin, in various forms, which attack the surface of the silver and cause the formation of a thin layer of the black sulphide.

Readers of the course on PHYSICS are now familiar with the "three states of matter," and will not be surprised to hear that at sufficiently high temperatures silver is found in the form of a bluish gas.

The "Nobility" of Gold. This more or less familiar element is closely allied in its properties to those we have previously discussed. It is pre-eminently the noble metal, remaining unchanged in the presence of even moist air, and, indeed, declining to undergo direct oxidation under any conditions whatever. It is very ductile, tenacious, and malleable. Copper, silver, and gold, indeed, are all so malleable that they can be beaten into films that will transmit light, and the thinness to which gold-leaf may be reduced is almost incredible.

A reference to the table in an early lesson will remind the reader of the very great weight of gold. Its atomic weight is rather more than 197. Though gold is so scarce, has such a fine lustre, is so "noble," and is the only yellow metallic element, it is by no means the dearest of the elements. Compared with radium, for instance, it is "dirt cheap." It is even more resistant to chemical action than the other members of this group. The powerful acids, for instance, such as hydrochloric, nitric, and sulphuric acids, will each dissolve copper, but the only means by which gold may be made to yield to them is by the combined action of nitric and hydrochloric acids. The mixture of these two acids, being able to dissolve gold, has been known for many centuries as *aqua regia*, which we may translate as the regal fluid. The compound formed when gold is thus dissolved is called auric chloride, and has the formula $AuCl_3$.

Gold occurs in nature chiefly in its elemental state; its distribution is very wide, though the total quantity is so small. For instance, it occurs in minute quantities in iron pyrites (FeS_2), and in galena, the sulphide of lead (PbS), of which we have already made the acquaintance. Extremely minute traces are found in sea-water.

The Possible Making of Gold. We are all familiar with the fact that the alchemists spent long years in seeking the philosopher's stone which would turn all the base metals into gold. Probably every reader in his time has had his laugh at these vain efforts; and certainly we may agree that there is no such philosopher's stone. But we are now coming to see that the alchemists were not so far wrong after all. They believed that under the differences which the elements display there must be an essential similarity, and we know now that they were right. It is especially that extraordinary element radium, of which we shall have much to say later on, that has taught us to regard the transmutation of the elements not merely as possible, but as, in at least two known cases, an observed and proven fact.

The New Alchemy. So far, all the evidence of such changes that has been established is concerned with downward changes—that is to say, changes from heavier and more complex elements towards lighter and simpler ones. On the other hand, there is no theoretical impossibility in the performance of the reverse process.

There is, indeed, every indication that chemistry is now upon the brink of quite incalculable possibilities. It was at these that the co-discoverer of radium, the late M. Curie, was hinting when he came over from Paris, shortly before his death, to receive a gold medal from the Royal Society. In acknowledging the honour that had been paid him he jokingly remarked that he would do his best to see whether he could not turn the medal into radium.

Ten years ago such a remark would have been a pointless absurdity, but now it is very significant. The work of Madame Curie and others has shown us that the atomic weight of radium is heavier than that of gold; and if gold or any other element, often of far more intrinsic value than gold, is to be produced by transmutation, the element to be transmuted is more likely to be one that is more complex and heavier than gold. It will not be long before phrases like "analysis of the elements" and "synthesis of the elements" make their appearance in text-books. We are on the brink of the *New Alchemy*.

C. W. SALEEBY

THE DEVASTATING ONSLAUGHT OF THE PLUNDERING MAGYARS TEN CENTURIES AGO

THE MAGYARS BURSTING INTO THE DISTRICT OF THE DANUBE AT THE CLOSE OF THE NINTH CENTURY

The Crushing of the Empire between the Northern Barbarians and the Conquering Turk

THE RUINS OF EMPIRE—AND CHAOS

CHARLEMAGNE, great as he was, had not inaugurated the Golden Age. In fact, the eight hundreds and nine hundreds, the two centuries after the coronation of Charlemagne at Rome, were in some respects darker than any that had preceded them.

This was partly due to the weakness of the rulers. The descendants of Charlemagne were not nonentities, like the Merovingians, but they were for the most part selfish and turbulent princes; and only a very strong hand grasping the imperial sceptre could have kept the discordant elements of that vast empire in orderly subjection.

Such a strong hand was emphatically not possessed by Charlemagne's son and successor, Louis the Good-natured. His sons revolted against him and quarrelled among themselves. France, Germany, and Italy sprang apart, and began those separate lives of theirs which still continue; and not only so, but in each country the principle of disintegration was at work. Counts and barons who should have been mere officials appointed for life or during good behaviour became hereditary nobles; in short, Feudalism was born. Amid all these changes the stately vessel of the Carolingian dynasty went hopelessly to pieces, the last direct descendant of Charlemagne who reigned as emperor in Germany being dethroned in 887, the last who was king of Italy dying in 950, the last who was king of France in 987. Out of the driftwood of the family, the representatives through females and the illegitimate descendants, almost all the reigning dynasties and a large part of the still powerful ducal and baronial houses of Europe have been constructed.

Chief, however, among the causes which made Europe miserable were the ravages of the Scandinavian pirates, the Danes as the English called them inclusively, who seem at the end of the seven hundreds to have suddenly awakened to the fact that there were fair lands to the south of them with rich booty, which it needed but good seamanship and well-organised robber-raids to make their own. The *Here*, as the great pirate army was called, visited England at longer or shorter intervals throughout the three centuries from 787, when they first landed in Wessex, till 1066, when Harald Hardrada invaded Yorkshire, and fell before his namesake Harold, son of Godwin. Later in this chapter we briefly relate the story of the victories and defeats which marked the struggle of the Danes with Alfred the Great from 871 to 900, of their subjugation by Edward the Elder and Athelstan from 900 to 940, and of the success with which under their king, Canute, they fastened the Danish yoke upon the neck of the English, so that it seemed for a time probable that our island would be but a humble member of a great Scandinavian empire, dominating the Baltic and the North Sea.

We must not omit to call attention to the fact that in these three centuries of conflict the pirates themselves greatly changed their character, and from barbarous pagans became a Christian and civilised power; also that they settled in large numbers in the north-eastern part of England and added undoubtedly a valuable element to the population of Northumbria and Mercia. Moreover, the fierce attacks of these dreaded invaders helped to unify the Anglo-Saxon state.

When all the other kingdoms of the so-called Heptarchy had gone down before the ruthless *Here*, Wessex alone successfully resisted their onslaught, and therefore it is that from the royal house of Wessex the present king of England is descended. It is not, perhaps, sufficiently remembered how sorely the scourge of the Danish invasions smote France and Germany as well as England. Wherever there was a broad estuary of a river, there the keels of the Danes might be looked for; the Elbe, the Seine, the Marne, the Loire, the Garonne, all saw the Dragon-standard of the Vikings mirrored in their waters. Aachen, Charlemagne's own capital, was sacked. Rouen was taken. Paris was once taken and once suffered a terrible two years' siege (885-886). In fact, throughout the eight hundreds it

would be hard to say whether England or France suffered the most from the ravages of the terrible Northmen.

Results of the Scandinavian Invasion. But in France the most memorable result of the Scandinavian invasions, the settlement of the Northmen in the fruitful lands at the mouth of the Seine, tended eventually to benefit rather than to injure civilisation. In the early nine hundreds Rolf the Northman closed a life of piratical adventure by becoming the "man" of the Frankish king Charles the Simple, and condescending to receive from him the fair province which has ever since borne the name of Normandy. His descendants, appropriately named the "Long-sworded," "the Fearless," and the like, embraced Christianity of the militant type then fashionable, inhaled the new air of chivalry, and became in some respects its typical representatives. The converted Scandinavian pirate seems to have been a finer specimen of humanity, more chaste, more temperate, and more devout than either his Frankish or his Saxon neighbour, but also more ruthless, more grasping, a "better man of business." He was the keen, well-polished steel, while they were but the clumsy iron weapon. Thus, it was only in the natural order of things that when, in 1066, William the Bastard, Duke of Normandy, landed on the coast of Sussex, his rival, the Saxon Harold, Godwin's son, should fall before him in the battle which bears, not with strict accuracy, the name of Hastings.

The Northmen's Dynasty in Sicily. But memorable as this Norman conquest, which placed a new dynasty on our throne, and introduced a fresh social and political order, must ever be to Englishmen, it is important to remember that it was not by any means the only Norman conquest which Europe witnessed in that age. From the beginning of the ten hundreds, Normans, half pilgrims, half warriors, had been making their way over the Alps and Apennines into Southern Italy. They had mingled as auxiliaries in the endless contests which were going on in that region between Lombards, Greeks, and Germans. At length, in the year 1038, William of the Iron Arm, eldest of the twelve sons of a Norman knight, Tancred de Hauteville, made his prowess felt in a battle with the Saracen lords of Sicily. He obtained the dignity of Count of Apulia. One after another the sons of that prolific Norman house appeared upon the scene, eager to share his fortunes.

Robert Guiscard, the sixth brother, made himself supreme in Southern Italy, dealt fierce blows at the Eastern Empire, took the Pope of Rome, Leo IX., prisoner in battle, and soon afterwards became the vassal of his successor. Meanwhile, his brother Roger, the youngest of the tribe, by his victories over the Saracens, was building up a more enduring dominion in Sicily, and preparing the way for a royal dynasty which, in the eleven and twelve hundreds, was powerfully to influence the fortunes of the whole of Europe, And these Norman conquests in the Mediterranean lands were, be it remembered, strictly contemporary with that other Norman Conquest with which we are familiar as forming the greatest landmark in our history.

Saracen Sea-Power in the Mediterranean. In order to follow the fortunes of the Northmen, we have come down to the end of the eleventh century; but we must, for a little while, remount the stream of time in order to notice other calamities which were distressing Europe.

In the eight hundreds, the danger to Europe of Mohammedan conquest was more menacing than it had ever been since Charles Martel won the battle of Poitiers. For the Saracens had now become a great sea-power; probably, in the decay of the maritime strength of the Eastern Empire, they became the greatest sea-power of the Mediterranean.

In the year 831 they overran and conquered Sicily, which remained theirs for more than two centuries till, as just related, it was won back for Christianity by Roger the Norman. Fifteen years later they appeared at the mouth of the Tiber; Ostia was taken, the Campagna wasted. St. Peter's itself was desecrated and robbed of the treasures of centuries; St. Paul's Without the Gates shared the same fate; the city of Rome itself only just escaped being handed over to a Mussulman emir and echoing the cry of the muezzin. It really seemed as if Mahomet's, rather than Christ's, was to be the holiest name in all the Mediterranean lands. And this lamentable eclipse of the glory of the new empire was witnessed by a generation many of whom must have gazed on the living face of Charlemagne.

The Nightmare Terror to Europe. While the Saracens still threatened by sea, a more terrible, because more barbarous, foe spread desolation by land. Over the vast Danubian plains, where Attila and his Huns once encamped, the Magyars, or Hungarians, a race perhaps remotely connected both with the Huns and with the Turks, now came thundering and destroying. From 889 till 933, when they were defeated by the Emperor Henry the Fowler in the great battle of Riada, the Hungarian squadrons were a nightmare of terror to Europe. They overran Germany, Burgundy, and Southern France, crossed the Alps into Italy, burned Pavia, and threatened, but did not take, Rome. From many a terrified congregation in the churches of Italy went up the heart-breaking litany: "From the arrows of the terrible Hungarians, good Lord, deliver us." By the middle of the nine hundreds, however, they were beaten down into a reasonable frame of mind; they became civilised and Christianised. In the year 1000 a royal saint, Stefan, received from the Pope the title of King of Hungary, and in later centuries the brave and chivalrous Magyar was the great bulwark of Europe against his Mohammedan kinsman, the Turk.

The Degradation of the Papacy. Beside the miseries of barbarian invasion, Europe, after the collapse of the dynasty of Charlemagne, suffered from religious terrors. As the years wore on towards the fateful era of the thousandth

from the Birth of Christ, a presentiment brooded over the nations that the end of the world was at hand. When they needed most the support of religious faith, their spiritual guides most signally failed them. These centuries, the eight hundreds, the nine hundreds, and the early ten hundreds, are admitted by all historians to have been the time of the deepest degradation of the papacy. A long succession of utterly insignificant Popes is followed by one man of eminence, perhaps of genius, Pope Formosus (891–896), but he was a violent political partisan, accused of complicity in the murder of one of his predecessors; and his dead body, having been dressed in papal robes, and subjected to the indignity of a trial, was mutilated by order of a solemn council, stripped, and thrown into the Tiber.

The Church under Feminine Control. Then came the period of the ascendancy of two infamous women, a mother and a daughter, Theodora and Marozia, who for over sixty years (901-964) placed their lovers, their sons, and their grandsons in the chair of St. Peter. After an interval the Counts of Tusculum, petty feudal princes in the neighbourhood of Rome, succeeded in making the papacy a virtual appanage of their house (1012-1048). With such men, licentious and profane, sitting in the holiest place of Western Christendom, the reverence which in the days of Gregory the Great had waited upon the lightest word of "the Apostle" was rapidly departing.

The Empire's Fluctuating Power. The cure for the worst miseries of this anarchic age came this time from Germany. The old Frankish Empire, it is true, had split into pieces. France especially, after the deposition of Charles the Fat, in 887, had been drawing further and further away from the empire, and when, a century later, a new royal dynasty ascended the throne in the person of Hugh Capet, she no longer, even nominally, formed part of it. Still, however, the great political fabric founded by the joint action of Charlemagne and Leo kept its proud title, "The Holy Roman Empire," though now it virtually included only the two countries of Germany and Italy, divided into an infinite number of petty feudal principalities, over which "Cæsar"—as the emperor was styled—wielded a strange and not easily defined dominion, strong and stern in the hands of a man of firm will and with the trick of success, shadowy and of little or no account in the hands of a weakling.

THE GREAT SIEGE OF PARIS BY THE NORTHMEN IN THE YEAR 885

Strong Emperors and Weak Popes. To the former class of strong and successful rulers belonged the Saxon emperors, who wore the imperial diadem during the nine hundreds and whose most celebrated representatives were Otho, or Otto the Great, the final vanquisher of the Hungarians, and his son and grandson, who

bore his name (Otto I., 936–973; Otto II., 973–983; Otto III., 983–1002). These strong rulers ended the political anarchy which had for a hundred years prevailed in Italy, where petty princes of Provence, of Spoleto, of Friuli, in rapid and unremembered succession, had reigned as shadowy kings. In the ecclesiastical realm also they restored a certain measure of order. In 963 Otto the Great summoned a council to meet in Rome, by which Pope John XII., a profligate and tyrannical youth, grandson of the licentious Marozia, was solemnly deposed, and a layman of decent life, a papal secretary, Leo VIII., was chosen in his stead. Still, however, the war of Roman factions continued, and one tumultuary pontiff followed another in rapid succession, till, in 996, the boy-emperor Otto III. placed his cousin Bruno of Carinthia, little older than himself, but a young man of pure and noble character, on the papal throne. Too good for the corrupt ecclasiastics and populace of Rome, this German Pope died in the last year of the nine hundreds, the victim, it was said, of poisonous conspiracy. Ere long followed that degrading dynasty of Tusculan Popes to which reference has already been made.

The Purification of the Papacy. It seemed as if nothing could save the office, once the most venerated in Christendom, from its moral suicide, when help was once more invoked from beyond the Alps, and this time with success. Another German, Bruno, of noble descent, was raised to the papacy by the Emperor Henry III. A saint and a mystic, the new Pope, who took the name of Leo IX., did much in his six years of rule (1048–1054) to raise the reputation of his office from the slough into which it had fallen. Unfortunately for him, he resorted to carnal weapons for the defence of his territory against the Norman Guiscard, by whom he was defeated and made prisoner. The vexation of his defeat and the hardships of his captivity probably hastened his end, for he died the year after the battle, but the moral uplifting which he had given to the popedom survived its author for generations.

Between the Bulgar and the Turk. Turning now to take up the thread of the narrative in the East; when the Empress Irene had been deposed and shut up in a convent, some time elapsed before a fresh dynasty was established. One of the intervening emperors, Michael, very much annoyed his subjects by recognising the imperial title of Charlemagne. Also, when he went to war with the Bulgarians, who by this time offered the most serious menace to Constantinople, he was badly beaten. Consequently he was deposed, and Leo V., "the Armenian," became emperor.

Leo, though not a fanatical Iconoclast, offended the Iconodules, and although he made up for the incapacity of his predecessor by striking so hard at the Bulgars that they remained quiet for a whole generation after him, he too was assassinated, and the soldiers made Michael II. emperor.

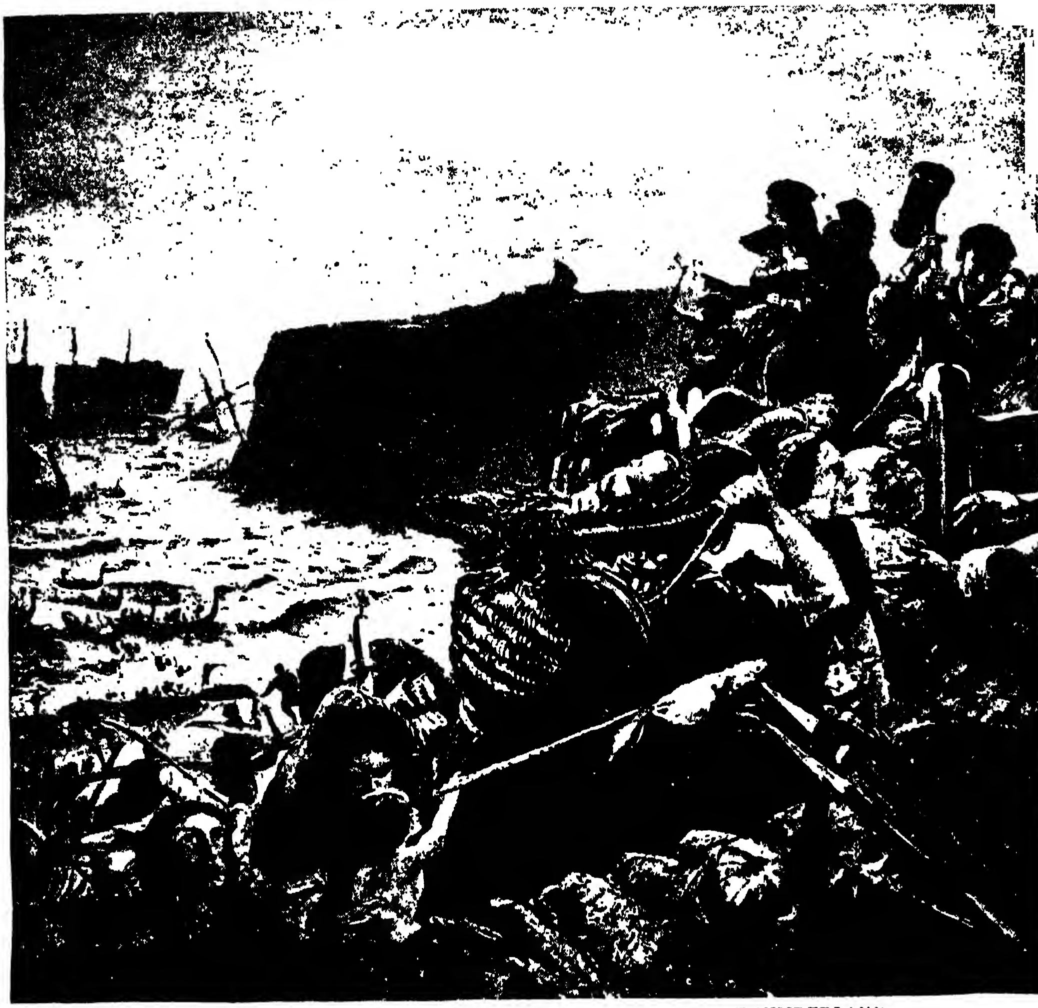
It was about this time that the Saracens were effecting that conquest of Sicily to which reference has already been made. Sicily lay nominally within the area of the Eastern Empire, but Michael and his son and successor, Theophilus, found themselves unable to send any effective assistance to the island.

The Separation of the "Catholic" and "Greek" Churches. The splendour of the Bagdad khalifate had not yet waned, though it was not destined to last long. Harun al Raschid's successor, Mamun, was an energetic ruler, anxious to maintain the aggressive tradition. Consequently it was upon the Asiatic boundaries of the Greek and Moslem empires that the struggle was now waged, and Theophilus could not spare troops for the West. For many years there was almost ceaseless warfare, and little practical result. After the death of Theophilus, a competent ruler though a fanatical Iconoclast, his widow governed for some time on behalf of their young son. That son, when he came of age, was shortly afterwards murdered by the favourite whom he had himself associated in the imperial dignity, Basil the Macedonian, the founder of a dynasty which lasted some two hundred years. The distinguishing event of the reign of Michael had been the final breach between the Roman and the Greek Churches, the "Catholic" and the "Orthodox."

An Automatic Government. Basil, in spite of his crime, was a capable soldier, who strengthened his frontiers and to a great extent freed the Eastern Mediterranean from the fleets of Moslem corsairs which had infested it. He did not, however, deliver Sicily, though he did clear the Saracens out of Southern Italy, where they had been winning a foothold. The reigns of Basil's two immediate successors, Leo VI. and Constantine, called Porphyrogenitus, are distinguished chiefly by the fact that the emperors were men who cared more for art and literature than for war or statecraft. In fact, at this time it might be said that the mere machinery of government had been so far perfected in the Eastern Empire as to work almost automatically.

Facing Turk, Russian, and Bulgar. In the Far East, on the other hand, the Abbaside khalifate was tottering. Mamun had been responsible for introducing the employment of a great bodyguard of Turks from the uncivilised Central Asian outskirts of his dominion, and the Turkish soldiers were learning to regard themselves as the real masters. On the other hand, a Persian family established themselves at Bagdad as the protectors of the khalif; and they, in fact, became practically a reigning dynasty. So it befell that soon after the middle of the tenth century, when the child Basil II. was nominally emperor at Constantinople, two soldiers in succession, Nicephorus and John Zemisces, exercised the real power, even bearing the title of associate emperors, and were able to win back some Syrian territories from the khalifate.

John Zemisces, however, found occupation in beating off the attacks of the Russians; and after his death, when Basil II. took the reins of government into his own hands, the great struggle of his reign was that with the Bulgarians, which he



A DESCENT OF THE DANES UPON THE COAST OF NORTHUMBERLAND

THE EXPULSION OF THE DANES FROM MANCHESTER

The upper picture is by W. Pell-Scott, and is in the Victoria and Albert Museum ; the lower, by Ford Madox Brown, is in the Manchester Art Gallery.

conducted so successfully and so mercilessly that he became known as "Basil the Bulgar Slayer."

The Rise of the Turkish Tribes. After Basil's death in 1025, there ensued a long period of more than fifty years during which the imperial sceptre changed hands repeatedly, and the only period of decent rule was that enjoyed for three years under Basil's niece, Theodora. In 1078, a new dynasty was inaugurated by the elevation to the purple of the crafty and capable, but far from admirable, Alexius Comnenus.

Meanwhile the Turkish tribes had been becoming more and more a menace to the Abbasides and their Persian ministers or masters. Men of Turkish race, too, had been rising to prominence. One of these, Sabuktegin, became governor of a province in what is now Afghanistan, with his capital at Ghazni. At the close of the tenth century he was succeeded by his son, the famous Mahmud of Ghazni. Ghazni had already been made virtually an independent kingdom.

The Great Mahmud of Ghazni. Mahmud, a mighty warrior and a fanatical Mohammedan, did not throw off his allegiance to Bagdad; but while the power which he developed made him during his life a bulwark against the invasions of Turkish hordes, he has two other titles fo fame. He invaded India no less than fourteen times, swept through the Punjab, carried his arms eastwards across the Ganges, and on another occasion struck southward as far as Gujerat. He laid low countless temples and idols; he swept up vast quantities of treasure. He did not, in fact, attempt anything in the nature of an organised conquest; his incursions were merely raids on a huge and terrific scale. But he did initiate the occupation of the Punjab by successive dynasties of Afghan or Turkish captains.

The other feature of Mahmud's rule is that, while his wealth was rendered enormous and almost unparalleled by the vast spoils which he collected in India, his Court became proverbial on account of the encouragement which he gave to learning and literature, as well as architecture. Every contemporary poet or scholar possessed of any sort of title to recognition was welcomed at Ghazni, and was amply endowed out of the enormous treasures carried off from the temples of the idolators.

The Turkish Occupation of Palestine. After Mahmud's death in 1030, it was not long before the power of the Ghaznavide dynasty was challenged and virtually displaced by that of the house of Ghor. . But more serious for the world at large was the fact that the group of Turkish tribes called the Seljuks were immediately overrunning Persia, dominating Bagdad, where they took upon themselves to become the khalif's protectors, swept up to the confines of the Greek empire, broke through the Taurus, occupied the east of Asia Minor, and drove westwards over Syria till they made themselves masters of Palestine and the Holy Places revered by all Christendom. The insults and severities inflicted by the Turks upon Christian residents and pilgrims were the occasion, if not the actual cause, of the Crusades.

The Unconquered North of Britain. From the East we turn to our own island to sketch the story of its transformation from Celtic Britain into England and Scotland. For three and a half centuries from the time of Claudius the Romans had occupied the island, holding it in force as far north as the Tyne and the Solway, and maintaining outposts between Tyne and Forth, though never really subjugating the Northern territory. The Celts of the north were Gaels, though whether the large Pictish population are also to be regarded as Gaels is an open question. The Celts of the south were Brythons, better known as Britons. The Britons acquired a Latin veneer, but nothing more save some of the elements of Roman law and the Christianity of the fourth century.

The Coming of the Jutes. When the Roman legions had retired, and the Roman emperor Honorius announced that they would not come back again, the Britons fell back into something like their old tribal organisation of petty principalities. The coasts and the northern border had long been harassed by pirates from Friesland and Schleswig of the Teutonic stock, and by the Caledonian Picts, and the Scots, Gaelic tribes who had migrated from Ireland, to which the Romans had never penetrated. About the middle of the century the Teutonic pirates began to land in force with the intention of permanent settlement; tradition says that the Jutish captains, Hengist and Horsa, were first invited by a southern prince to help him against the Picts, with whom he can hardly have had much to do. At any rate, the Jutes did settle in Kent, probably in Hampshire, and possibly elsewhere.

The Coming of the Saxons and Angles. Before the end of the century the kindred tribes of the Saxons were following the Jutes, and attacking the south coast; in the first half of the sixth century the Angles were invading the eastern coast from the Thames to the Forth. The Britons were beaten back before the invaders; in some places they were literally exterminated, in others they beat a gradual retreat. The evidence on the whole is that only a very small remnant of the British population remained in the conquered territories. The conquest was emphatically gradual.

About the end of the fifth century it met with a severe check; it is probable that the mythical King Arthur was actually a captain who did inflict severe defeats upon the invaders. The Britons, however, were definitely driven back into the west country; into Cumbria between Solway and the Mersey; behind the Severn and the Avon; and into the south-western peninsula, called West Wales or "Damnonia," though for many years there was a debatable land, devastated and hardly populated, between the British tribes and the German tribes.

Tribal Divisions. Then the invading tide rolled forward again. In the third quarter of the sixth century the West Saxons in the Thames valley and to the south of it pushed out till they

reached the Bristol Channel, and cut off the Southern Britons from their kinsfolk in Wales. It was not till early in the seventh century that the Northern Angles in like manner drove a wedge up to the mouth of the Mersey separating Wales from Cumbria; by which time Angles and Saxons had probably occupied the whole of the midlands. The first established Kentish kingdom had maintained its position, and was more highly organised and civilised than any of the other groups which were now shaping into kingdoms. Of these only two as yet are recognisable, Wessex, extending from Hampshire to Severn mouth, and Northumbria, extending from the Humber to the Forth—to which perhaps may be added the South Saxons in Sussex, who were isolated from the rest by geographical conditions. In the middle of the century however, Northumbria was again united under Oswy, a prince who overthrew Penda, and whose supremacy was acknowledged over all England north of the Thames. Under Oswy practically all England became decisively Christian, and attached itself to the Latin Christianity which recognised the supremacy of Rome instead of the Celtic Christianity which was unorthodox.

The Rise of Wessex. At the beginning of the eighth century the King of Wessex was supreme over the minor kingdoms on the south of the Thames; the King of Mercia was in effect overlord also of East Anglia and Essex; and the King of Northumbria ruled beyond the Humber. But Northumbria was falling to pieces; towards the end of the eighth century Offa, King of Mercia, was practically overlord of the whole island except Wales, Cumbria, or Strathclyde, and Damnonia—that is, Devon and Cornwall—Wessex owning his overlordship though it had its own king. But just after the opening of the ninth century the crown of Wessex passed to Egbert; five-and-twenty years later Egbert had overthrown the power of Mercia, and the King of Wessex was in his turn recognised as the overlord of all Britain.

THE FIRST ENCOUNTER OF THE SHIPS OF ALFRED, THE FATHER OF THE ENGLISH NAVY, WITH THE DANISH INVADERS OFF THE COAST OF DORSET IN 877

The Gradual Predominance of the North. At the close of the sixth century there came to Kent the Roman missionaries despatched by Pope Gregory the Great, under the leadership of Augustine. Kent was readily converted, and early in the seventh century, as we have already seen on page 1370, the new religion spread into East Anglia which now also appears as a definite and perhaps a predominant kingdom. By the second quarter of the century, however, the predominance was passing to Northumbria, of which the two divisions, Bernicia and Deira, were united under a powerful monarch Edwin. Northumbria adopted Christianity, but her power was broken for a time by the obstinate heathen Penda, who had made himself king over the Midlands, or Mercia.

The English Power of Egbert. From Egbert dates the supremacy of the house of Wessex; his descendants after Alfred the Great became kings of all England; and the blood of Cerdic, the mythical founder of the house of Wessex, runs in the veins of George V. We have little space to trace the development of

England and Scotland in the days from Egbert to the Norman conquest of the southern country and the establishment of the dynasty of Malcolm Canmore in the north. Of Ireland, it could hardly be said that there was any development; her palmy days had been in those earlier centuries when her missionaries went forth to spread Christianity in neighbouring and also in distant lands. Ireland lay politically apart, and her tribes never attained to any union as an organic political entity.

It is evident on the other hand that Egbert did succeed in establishing a really effective rule over the south and most of the midlands, while the East Anglian rulers were his lieutenants, although he did not apply his powers of organisation to Northumbria. Before the end of his reign the attacks of the Northmen upon the south coast were becoming ominous, though they were always beaten back to their ships. In the days of his son, Ethelwulf, the Danish host more than once wintered in England.

The Repulse of the Danes by Wessex. In the days of Ethelwulf's sons, the Danes made themselves masters of Northumbria and East Anglia, although when they fell upon Wessex they were beaten back after a long struggle by the great King Alfred, remaining, however, in effective possession of that half of England which was called the Danelagh. In the tenth century Alfred's son and grandsons brought the whole of the Danelagh under their dominion.

In the meantime the Picts and Scots who occupied nearly the whole of what we now call Scotland, with the exception of the eastern lowlands, had become more or less united under the chiefs who were called kings of Scots. In the eastern lowlands it may be that Angles and Danes predominated over their Celtic predecessors. Some kind of vague supremacy on the part of the king of England was admitted by the king of Scotland, who "took him as father and lord," but otherwise paid very little attention to his behests.

The Union of Danes and Saxons. Attacks from the Northmen overseas had ceased for three-quarters of a century, but at the end of the tenth century, when the incapable Ethelred the Redeless was on the English throne, they came again. Ethelred's attempts to buy them off merely resulted in fresh attacks and fresh demands for ransom. Finally, King Sweyn of Denmark expelled Ethelred, and on his death, immediately afterwards, his son Canute united England to an empire which, before his death included Norway as well as Denmark.

When Canute's sons died, no attempt was made to prevent the English from recalling to England Ethelred's son Edward, known as the Confessor. It is needless here to relate the familiar story how, on Edward's death, the English made Harold Godwinson king and how William of Normandy came with his magnificent army across the English Channel and overthrew Harold and his army on the field of Senlac, and established the Norman supremacy in England.

It should be noted, however, that during Edward's reign Malcolm Canmore successfully asserted his claim to the crown of Scotland, which from that day to this has been worn by none save his descendants. A. D. INNES

THE LAST STAND AT SENLAC—KING HAROLD DEFENDED BY HIS BODYGUARD AGAINST THE HORSEMEN OF WILLIAM THE NORMAN

Road Development. Legislation affecting Roads. Construction, Cleaning and Upkeep. Road Board Tests for Materials.

ROAD MAKING AND MAINTAINING

Whether in ancient times better roads and pavements were built than at present, or whether only the best ones remain, is uncertain, but it is certain that some of the remains of such structures found in Rome, for instance, evince engineering skill of high degree. These were laid out carefully, excavated to solid ground, or, in swampy places, made solid by piles. Then the lowest course was of small-sized, broken stones, none less than 3 in. or 4 in. in diameter; over these was a course, 9 in. thick, of rubble or broken stones cemented with lime, well rammed; over this a course, 6 in. thick, of broken bricks and pottery, also cemented with lime; upon this was laid the *pavimentum*, or pavement, composed of slabs of the hardest stone, joined and fitted together as closely as possible. This was costly—the Appian Way, extending from Rome to Capua, a distance of about 130 miles in length, having almost exhausted the Roman treasury—but it was as enduring as Nature's own work. In Peru and Central America similar remains, 1000 to 2000 miles long, were found by the Spaniards, which, as Prescott says, were built of heavy flags of freestone, and, in some parts at least, covered with a bituminous cement which time has made harder than stone itself.

Early English Roads. Road-making in England may be said to have begun in 1346, when Edward III. authorised the first toll to be levied for the repair of roads leading from St. Giles in the Fields to Charing Cross (then a village), and from the same quarter to near Temple Bar. The footway at the entrance of Temple Bar was impeded by thickets and bushes, and in wet weather almost impassable, and the roads westward were so bad that when the sovereign went to Parliament faggots were thrown into the ruts in King Street, Westminster, to enable the royal coach to pass along. The first Act for paving and improving the City of London streets was passed in 1532. The first turnpike road established by law was in 1653. This was made for taking toll of all but foot-passengers on the northern road through Hertfordshire, Cambridshire, and Huntingdonshire.

But no very considerable improvements in the art of road-making took place till the Highland Rebellion of 1745, which gave a great impetus to the construction of roads for military as well as for civic purposes, as is evident from the fact that from 1760 to 1774 no fewer than 452 Acts regarding making, repairing, and improvement of highways were passed.

Macadam. John Loudon Macadam, the great road-maker, was born on September 21st, 1756. During the early years of the nineteenth century he was travelling about the kingdom, making inquiries into the systems of road-making. By August, 1814, he had travelled 30,000 miles, and had spent from his own private resources a sum equal to £5019.

In 1823 he succeeded in getting an inquiry before a Committee of the House of Commons as to his system, and had made a set of road-making implements, so that he might the more clearly explain the principles he advocated, and in 1825, having proved an expenditure of several thousand pounds from his own resources in carrying out his improvements, this amount was reimbursed to him by the Government, together with an honorary tribute of £2000.

Macadam's system of road-making, to use his own term, was "to put broken stone upon a road which shall unite by its own angle so as to form a solid, hard surface." His practice was to lay flints or some other hard material, broken to a uniform size of approximately cubical shape, 1½ in. to 2 in. in diameter, to the depth of 10 in, the only preparation being the levelling of inequalities and the digging of side-drains, the broken material being spread evenly over the road surface and left to be consolidated by the traffic. He used no admixture of binding material, and the stones were perfectly clean. This rule of Macadam, which in theory appears all right, in practice is found impossible to accomplish.

Telford's Highland Roads. About the same time that Macadam was busy engaged in his system of road making and repairing, another pioneer, Telford, was equally busy constructing many miles of roads in the Scottish Highlands, but on an entirely different system. Telford did not believe it possible to construct a hard road by simply laying 10 in. of broken stones upon a soft natural foundation, his method being to keep the broken stones from the subsoil, and to ensure this he first laid down a "pitched foundation," consisting of pieces of stones or other hard substance placed upon the level bed by hand to form a close, firm pavement, and upon this foundation was laid a thickness of broken road-metal.

Main, Rural, and Private Roads. The highways of England and Wales are divided among some 2000 local authorities. All roads which had been disturnpiked between December 31st, 1870, and August, 1878, or were subsequently disturnpiked, became *main* roads under the Highways and Locomotive (Amendment) Act, 1878. Some of the existing roads or portions of roads, although dignified by the term "main," are not "principal" roads, but, being old turnpike roads, whose days of importance have passed away, have now very little traffic on them. By the Local Government Act, 1888, County Councils, who were previously only contributing authorities, were charged with

entire responsibility for the maintenance of all main roads. In the provinces public highways are managed by City, Town, and Urban District Councils, while in the country they are managed by Rural District Councils.

Prior to 1835, so long as there was an intention on the part of the owner of the soil to dedicate a road to public use, which he signified by throwing open a road unreservedly, and an acceptance by the public signified by the using of the road, the two circumstances sufficed to make a road a public highway; but now roads and streets remain private—that is, not repairable by the inhabitants at large—until they are formally dedicated.

Breaking Up. The opening of roads for the laying of new mains, repairs to existing ones, or other public services is a continual cause of complaint, and one of the stock grievances of the public; and the damage caused to highways by openings made in them by builders, owners, and occupiers of property, and by gas, water, and other companies, is a source of much reasonable irritation and annoyance to Local Authorities who are responsible for their maintenance. A macadamised road opened for the construction of a trench can never be properly reinstated without showing some evidence of it, even when the replacement has been carried out by experienced roadmen. Where, however, other workmen have been employed, as those engaged by builders or house-owners, the damage is greater. The ramming of the materials in refilling the trench is most rarely executed in a sufficient manner, and instead of two men ramming being employed to one filling, which is necessary, and the materials being replaced in layers of not greater thickness than 6 in., ramming is generally performed in a most perfunctory manner—the material is replaced in large lumps, and as a consequence the trench subsides for weeks after. The substance of the sections giving statutory powers are collected into a short compress and in direct sequence.

Powers to Open Roads. The Gasworks Clauses Act, 1847, empowers the undertakers to open and break up any road, and lay down and place pipes, conduits, service pipes, and other works, and from time to time to repair, alter, or remove the same, subject to three clear days' notice being given to the clerk, or other officer of the Local Authority before beginning such work.

The Waterworks Clauses Act, 1847 (incorporated with the Public Health Act, 1875, sec. 57), provides similar power, and sec. 52 gives power to a private individual to open or break up so much of the pavement of any street as shall be between the water-main and his house, building, or premises, after giving due notice. It has been decided by the courts that the word *pavement*, as used in this section, is not confined to the footpath only. Provisos are also contained in the Tramways Act. 1870; the Railway Clauses Consolidation Act, 1847; the Electric Lighting Act, 1882; Forrest Fulton's Act (the usual title of the Water Companies Regulation of Powers Act, 1887), and the Telegraph Acts, 1863, 1873, 1878, 1892.

Quarries, Pits, and Pavement Regulations. Where any quarry dangerous to the public is in open or unenclosed land within 50 yards of a highway, or place of public resort dedicated to the public, and is not separated therefrom by a secure and sufficient fence, under the Quarry Fencing Act, 1887, the Local Authority has power to deal with it. The term *quarry* includes every pit or opening made for the purpose of getting stones, slates, lime, chalk, clay, gravel, or sand, but not any natural opening.

The following can be dealt with by Local Authorities as obstructions in streets:

(*a*) Shop and sun blinds if fixed less than 8 ft. in height.
(*b*) Trees overhanging roadways.
(*c*) Doors and gates opening outwards on the pavements.
(*d*) Defective rain-water shoots from buildings.

Where the Local Authorities do not undertake or contract for the cleansing of footways or pavements adjoining any premises, they may make by-laws imposing this duty on the occupier of any such premises. This is the substance of an important provision in the Public Health Act, which may place occupiers under some responsibilities which have not, perhaps, been considered. Yet there is ocular evidence on the pavement, day by day, opposite most greengrocers' and butchers' shops, of negligence in this matter. By the Public Health (London) Act, 1891, the City householders were relieved of this duty, which was cast upon the Sanitary Authority.

Asphalt. Although mineral rock asphalt was first discovered in 1712, it was not commercially adopted as a paving in Paris until 1854, and in London until about ten years later, and it is only in comparatively recent years that its wider uses have been appreciated.

Mineral rock asphalt is a natural product, a pure limestone naturally impregnated with mineral bitumen. The rock when mined or quarried is of a chocolate colour, fine in grain, evenly impregnated with bitumen, which varies from about 6 to 20 per cent. It is usually found in seams or layers from 6 ft. to 30 ft. in thickness, like coal, and is mined in a similar manner. The principal supplies are taken from the Bassin de Seyssel, Haute Savoie, Switzerland; France; Limmer, in Hanover; and Ragusa, in Sicily. The weight of a cubic yard of natural asphalt is about 34½ cwt. Trinidad asphalt is a colloquial term for the artificial asphalt pavement of America It is made with bitumen, sand, and limestone dust, resembling asphalt in its composition.

Use of Asphalt. During the last fifty years compressed mineral rock asphalt has stood the severe test of enormously increasing traffic in the principal streets of the City of London, the metropolitan districts, and the provincial cities and towns of the United Kingdom, and has proved to be the most satisfactory sanitary paving that can be laid. It is impervious to moisture, and non-absorbent, and, being jointless, nothing can get into crevices and decay. It has a smooth and even surface, is durable, economical, and quickly laid; and the preparation of compressed rock asphalt is similar to that of mastic asphalt for footpaths, except that the powder is placed in specially designed roasters with revolving cylinders, and heated to a temperature of about 280° F. without any admixture of bitumen.

As soon as the superfluous moisture has evaporated, the heated powder is placed in iron-sheathed vans, covered with thick cloths (to retain the heat), and taken to the site where it is to be laid. The asphalt powder is then laid on a Portland cement concrete foundation, 6 in. to 9 in. thick, according to the nature of the traffic, well raked over the cement concrete foundation, and rammed with hot rammers to the thickness required. After

being smoothed over with a hot smoothing-iron, so as to bring sufficient bitumen to the surface, a heavy roller is passed over it, while the asphalt is still warm, to straighten and consolidate the surface. When opened to the traffic, the asphalt gradually begins to be compressed into solid rock again. In main traffic streets 2½ in. of compressed asphalt are laid on about 9 in. of concrete. In streets of lighter traffic, the practice is 2 in. of compressed asphalt on 6 in. of concrete.

The Asphalt Road. An asphalt road can be constructed exceedingly flat, because a slight gradient is sufficient for rapidly removing the surface water; moreover, the vehicular traffic distributes itself without risk over the entire width of the road, even close up to the gutters, which is not the case, to the same extent, on a stone road. It suffices if, from the apex, which is simply rounded off slightly, two straight lines are drawn as cross or lateral gradients, an extra fall being given to the gutters for a width of about 18 in. As a rule, a lateral fall of 1 in 70 will suffice for the roadway, increased to 1 in 50 at the gutters. For the longitudinal fall 1 in 60 is considered the limit up to which the slipping of horses need not be feared.

The following well-known formula for calculating the camber of asphalt roads has been employed for many years:

$$f = c\frac{S^2}{S-7}$$

where f = camber (versed sine of arc),
s = width of roadway between kerbs,
c = coefficient (= 0·012).

Therefore, the normal camber of a roadway 30 ft. wide would be $0{\cdot}012\,\frac{30^2}{30-1} = 0{\cdot}372$ ft. in the centre.

Foundation and Layings for Asphalt. The concrete for the foundation should be gauged, six of aggregate to one of Portland cement. The thickness should be regulated according to the weight it has to bear. London principal thoroughfares have a foundation of 9 inches in thickness. Other streets where the traffic is of a lighter nature have but 6 inches.

Granited rock asphalt has proved its great durability and sanitary advantages. The earliest of this class of work was carried out ten years ago. For some unexplained reason the North of England has shown the greatest enterprise in adopting this class of roadway. It is to be seen in and around "Cottonopolis."

The primary ingredient, mineral rock asphalt, is manufactured in block form for convenience in handling. It is usual to compound and heat the materials on the site. Briefly, the process is to melt the asphalt, using a small percentage of refined natural bitumen as a flux, and then to incorporate with it about 30 per cent. of clean dry ¼ to ½ in. gauge granite chippings, the mixture being subsequently raised to a temperature of 275° F. for laying. In the case of roads carrying heavy motor traffic this composition has been laid 2 in. thick on 6 in. of cement concrete with excellent result, at a cost of 10s. per superficial yard.

In order to meet the demand for an asphaltic material that can be laid without a special foundation, a material known as Rock Asphalt "Carpet" has been introduced. The chief use of the material is for re-surfacing old macadam roads. In its composition mineral rock asphalt obtained from Eschershausen, Germany, plays an important part, This asphalt is claimed to possess the properties of hardness and toughness in unsurpassed degree, whereby it is well adapted for road-surfacing work. An even bed is required for the composition.

An example of Rock Asphalt "Carpet" may be seen at Eltham, where a trial length has recently been laid for the Woolwich Borough Council. In this case the composition was applied in two coats, making a total thickness of 1½ in. The road carries all through-traffic to Dartford. A length has also been put down opposite the Chiswick Town Hall.

Bricks for Paving. Bricks as a material for street paving have received very little attention in England, although this country is justly celebrated for the quality of its bricks.

In Holland this class of paving has been in use for about 150 years, and in America about twenty years, where hundreds of miles have been laid in all sorts of ways and under varying conditions. Bricks obtained from Middlesbrough were laid in Liverpool as a trial in 1881, and a small piece of brick paving to form a carriage-way was laid at Cheltenham in 1900. This paving was laid on a sand cushion with a foundation of 6 in. of cement concrete, the bricks being grouted in with pitch.

Cork Asphalt. Cork asphalt is a compound consisting of bitumen and certain other materials, including cork. It has been used in different parts of the world for a number of years, and possesses all the necessary features which constitute a good paving material. It is durable and elastic, and, being non-absorbent to moisture, is therefore hygienic and sanitary. It is comparatively noiseless, and also non-slippery; and therefore it is unnecessary in wet weather to sprinkle the surface with sand or fine gravel, as is requisite with other pavements. The result of this is that there is a marked absence of mud, and, in dry weather, of dust. These properties make it invaluable for public roadways, especially as freedom from noise, dust, and such discomforts is an object. It is claimed that no other pavement possesses such valuable characteristics, and cork asphalt is thus pre-eminently suitable for all classes of traffic, horse, motor, or otherwise. It is manufactured in the form of homogeneous blocks of uniform size, and the surface, when laid, is regular and even. Frost does not so readily act on it as on other classes of pavement.

The first cost of cork asphalt compares favourably with that of other pavements, and the cost of upkeep is much less, owing to its durable nature. This class of road pavement has been largely used by H.M. Office of Works, by numerous provincial boroughs and corporations, and by the leading railway companies.

This pavement is manufactured in blocks similar to wood blocks in sizes from 9 in. by 4½ in. by 1 in. thick to 9 in. by 4½ in. by 2 in. thick. It is laid on a concrete foundation, its cost compares favourably with that of wood, and its average life is somewhat longer.

Gutta-percha Paving. Gutta-percha, like cork, is the ideal of noiselessness, but is in a very experimental stage as yet, and has hardly come within the scope of practical consideration. A small piece is laid at the entrance to Euston Station, London, and in small, short sections at Glasgow. The sheets are laid down at their sides upon a concrete foundation by strips of iron, which clasp the edges tight on each other. Indiarubber in large sheets about 1 in. in thickness has been introduced in Hanover as a material with which

to pave roads, and it has also been used in the courtyard of the Savoy Hotel, London.

Granite Setts. A street pavement composed of this material has been in use for many years. This system was introduced into the country by the Romans. The size of the paving-stones was, however, much larger than modern science finds necessary. One of the first granite pavements laid was that known as the "Euston pavement." This class of pavement consists of squared setts (the most general size being 6½ in. by 3½ in. by 5 in. to 7 in. long), laid on a concrete foundation consisting of cement concrete, the only reliable material. It should never be laid less than 6 in., while 9 in. will carry the heaviest traffic. The concrete should be composed as follows:

Six parts of screened ballast or gravel—all of which will pass through a screen of 2½ in. mesh—and one part of Portland cement, all thoroughly mixed upon a platform and used while in a semi-liquid state. The resultant mixture of one ton of cement, when mixed in the proportion of six to one, is about seven cubic yards of concrete. This will cover an area of 42 super. yd. 6 in. deep, and will take four labourers one day for mixing and laying.

Laying Granite Setts. As the concrete is laid in the trench the top surface should be brought to the proper camber with the shovel. For ordinary traffic, Aberdeen or Norway granites are largely used; these are bedded on a sand packing free from small stones or pebbles, and average 1 in. in thickness, and laid touching one another, each stone being so firmly bedded on the packing that it has not to rely on the next one for support, and the setts laid to break joint. The ramming requires careful supervision, as, in order to avoid the trouble of lifting badly laid setts, the men often try to get an even surface by ramming the high stones extra hard, and omitting to ram the low-lying stones, or stones inclined to give too much.

In the North of England and other places the joints are first filled with clean pebbles, after which the surface is well rammed, and then run with an asphaltic mixture, and covered with a layer of fine gravel, while in the South of England the finished surface is usually grouted over with a liquid prepared from sand and lias lime, or Portland cement, and well washed into the joints. No traffic should be permitted on a newly laid pavement of this class for 14 days. One ton of setts of the size mentioned will cover 3·6 superficial yards, and a pavior will lay an average of 30 superficial yards per day of 10 hours.

Armoured Roads. Sheffield has had more than an average experience of roadways laid on what is known as the "Durax" system (armouring existing surface with small setts). The total area of this kind of paving within the city is about 30,000 yards. Some such roads have been down for about five years under light traffic, and are now in excellent condition without having involved any cost in repairs. The paving has the advantage of possessing more elasticity than an ordinary paved "sett" road; in fact, it may be said that, while a strong granite pavement will break before bending, this lighter form will bend before breaking.

The Macadam Road. For this class of road [1] the ground is excavated in the usual manner to an approximate circular segment, and the foundation formed of "hard core," a term applied to a heterogeneous mixture consisting of chalk, broken stone, bricks, dry rubble, clinkers, and other dry and hard materials. The thickness of the hard core depends on the nature of the subsoil, but 6 in. may be regarded as the minimum thickness, and this should be consolidated by rolling, all hollow places being filled in and made level. Upon this, a thin layer of dug flints or gravel should be uniformly spread and consolidated.

Then, to receive and withstand the wear and tear of the traffic, a 6 in. coating of stones or granite, broken to pass all ways through a ring of 2½ in. internal diameter, should be laid down, and well consolidated by watering and rolling, a little binding material being lightly scattered and swept in over the surface on completion.

Material for Macadamising. It is almost impossible to lay down any hard and fast line as to the material to be used over the whole kingdom for this description of road, as nearly every English county produces descriptions of stone all suitable in a greater or less degree as a road-making material; but where the material is soft, it will be found economical to obtain a harder stone or granite from a distance, as the hardest description of stone should always be preferred. Those now commonly in use are basalt, Aberdeen, Guernsey, and other granites, Mountsorrel and Hartshill and Leicestershire stone. Picked slag, hill-picked surface and land-dug flints, and gravel, are also largely used for suburban side-streets and rural roads where the traffic is not heavy. The cost of granite as a road metal and flints or gravel is roughly as 1 to 3.

Cherbourg Quartzite in England. Until 1885, this material was little known in England. At that date, the first cargo was imported and laid upon a length of road situated close to Gravesend, and remained eight years without needing repairs.

The natural cautiousness of the English engineer when dealing with something which has not been proved has prevented this material from being classed with other granite as a road material.

Rules for Laying Macadam. A rule to find the area of surface that can be covered by one cubic yard of broken material is as follows:

When the metal is not rolled, divide 36 by the thickness of the proposed coating in inches; the quotient is the number of superficial yards that can be covered. When the metal is rolled, divide 27 by the thickness in inches to give the required quotient.

A commonly adopted rule for ascertaining the camber of a macadam road is as follows:

Width of road, say, 30 ft.

At	4 ft. from centre (on each side), fall	½ in.
,,	9 ,, ,, ,, ,, ,, ,,	2 in.
,,	15 ,, ,, ,, (its extreme edge),	6 in.

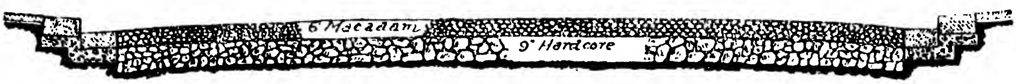
This class of road is repaired by the old, worn surface being picked up by manual labour, or by means of a scarifier, the new metal being put on and steam-rolled with a small addition of matrix.

Tar. While it is only within comparatively recent years that tar macadam has been applied to road-making purposes, it has been used in Nottingham, where the first piece of tar macadam was laid in this country, for some 50 years,

There is nothing new in the principle of mixing tar with road metal, but a material manufactured from the best hand-picked selected iron slag, and mixed by machinery specially designed, has been introduced to comply with the largely expressed desire for a tar macadam suitable for roadways, and is specially intended to meet the greatly increasing motor and other similar traffic which is now proving so damaging to the ordinary macadam road, principally due to the suction set up by the rubber tyres, which causes disintegration of the finer material.

Cost of Tar Macadam. With roads made of tar macadam, the initial cost is not very much in excess of that for ordinary macadam, while the life is considerably greater, thus largely reducing—by 40 to 60 per cent.—the cost of repairs and the expenses of scavenging. The material is non-slipping, and has been laid on slopes and cambers of as much as 1 in 30 without any more effect than on an ordinary macadam road.

Preparation of Roadway. The surface of the roadway or other area proposed to be paved should (in the case of an existing road or old foundation) be scarified by a steam scarifier, or picked over by hand labour and levelled, to leave a camber, or fall, of the cross section of ½ in. to ⅝ in. to 1 ft., care being taken to excavate all soft and weak places, which should be taken out at least 1 ft. in depth, and filled in with good, dry, hard core. The whole surface should then be moderately steam-rolled to ensure



1. TRANSVERSE SECTION OF A MACADAM CARRIAGE-WAY

thorough consolidation (a very essential point), but the rolling should be discontinued before the surface becomes "smooth," as a "key" is necessary, and an air circulation is required in the foundation. The tar slag-macadam is then laid on the foundation prepared as above in two coats of varying thickness, according to the traffic for which it is required, each coat being well rolled with steam-roller, weighing not more than six tons, and the surface on completion being dusted over with fine chippings, and finally well rolled until it is quite hard. The material of the *bottom* coat should be spread with shovels in the same way as ordinary macadam, and should be allowed to lie open before being rolled, for at least 24 hours, to allow it to become partially set and *tough*, which ensures the levels remaining true; and the *top* coat laid with rakes (kept heated) to enable a level and true surface to be obtained. This coat should also remain open a few hours before rolling, and, where possible, the rolling of the material should not be done during rain, or until it has had sufficient time to dry.

The thickness at which the material should be laid may be taken generally as shown below.

Roadways with local or through traffic: Work to be laid in two coats, totalling 4½ in. in thickness. Bottom coat, 3½ in. thick of 2-in. gauge material. Top coat, 1 in. thick of ⅜-in. gauge material.

Roadways with light traffic: Work to be laid in two coats, totalling 3½ in. in thickness. Bottom coat, 2¾ in. thick of 2-in. gauge material. Top coat, ¾ in. thick of ⅜-in. gauge material. The life of this description of paving may be taken as seven and five years respectively.

The practice of tarring the surfaces of waterbound macadam roads which have not sufficient traffic to justify their conversion to tar macadam is to be commended. The dressing mitigates the dust nuisance, and prolongs the life of the macadam.

Wood Paving. The first wood-paved roadway laid in London was in front of Old Bailey in 1839. Since this date wood has made giant strides as a street paving [2]. "It is admitted by all that it is of little use to lay any pavement without a good and substantial foundation, and none of the substances used requires this more than wood. Such being the case, a substantial concrete foundation is first laid, and it should cost the same, whether granite, wood, or other material be placed upon it; consequently, the only thing to be considered is the cost of the wearing surface, its lasting qualities, and its desirability as a pavement when completed."

Woods for Paving. A wood pavement as now laid consists of a good, hard foundation of Portland cement concrete, laid 6 in. thick, and floated over to an even surface, conforming with the contour line of the proposed finished road. When sufficiently set, rectangular blocks of Jarrah, Karri, or others of the eucalyptus or blue gum types, 9 by 6 by 3 in., on the face, cut die square, with the fibre vertical, are laid with close joints upon the finished surface of the concrete. To allow for the expansion of the wood transversely across the street, a 1½-in. expansion joint of sand is provided next to the kerb. The interstices between the blocks are often grouted with liquid Portland cement and fine sand, a bituminous mixture of tar and pitch, or tar alone. The mixture is poured over the surface and "squeegeed" or brushed until it disappears between the wood blocks. The surface is then sprinkled with coarse sand or fine grit, and the traffic allowed to squeeze it, thus preserving the wood and rendering it less slippery.

Creosoting the Blocks. If soft woods are used, the blocks should be creosoted by at least 10 lb. of creosoted oil being driven into every cubic foot of wood, so that each block may be thoroughly penetrated. The life of the blocks is not materially increased by the creosoting, but they are rendered less absorbent. The life of this pavement depends upon the amount of traffic, quality of the material used, the locality (whether open or confined), and the width of the street, but the average estimated wear of Jarrah or Karri blocks is ⅜ in. per annum.

Karri wood is hard, heavy, and tough, and it is recognised as one of the most durable woods for

2. TRANSVERSE SECTION OF A WOOD-PAVED CARRIAGE-WAY

street paving. It is cut from a tree whose average height is 200 ft. by 4 ft. in diameter at 3 ft. to 4 ft. from the ground, and has its first branches at a height of 120 ft. to 150 ft. The concrete foundation is similar to that described under Granite Setts.

Soft woods have been used mostly in London on account of their being less noisy under traffic than hard woods, but their chief objection is that they wear more quickly than hard woods.

The comparative expansion of creosoted against plain soft wood blocks after immersion in water for 48 hours has been found to be as follows:

On length of block	creosoted	·099;	plain	·6
„ width	„	·57;	„	·83
„ depth	„	·15;	„	·31

These represent, in a thirty-feet carriage-way, 2¼ inch for plain blocks and practically ⅜ inch for creosoted blocks, if under the same conditions.

Road Sanitation. The sanitation of roads is a question which has not received, by scientific and practical investigation, the attention as to its influence upon health demanded by its importance.

In 1856, when the Metropolis Local Management Act came into operation, there were no asphalt or wood-paved roads; steam-rollers were unknown, and the mud was up to one's ankles on a wet day.

Street Cleaning. The Public Health Act, 1875, contained provisions for the proper cleansing and watering of streets. The Public Health (London) Act, 1891, made it compulsory for every sanitary authority to employ a sufficient number of scavengers, or contract with any scavengers, for the execution of the duties of the authority under this Act with respect to the sweeping and cleansing of the several streets within their district, and the collection and removal of street refuse.

Street-sweeping by rotary brush machines drawn by horses is found to be 33 per cent. cheaper than if done by hand. It might be expected that, where streets have been paved to a very even surface with wood or asphalt, they should be kept much cleaner than they are, but the difficulty is that not only is mud and dust produced by the droppings on any particular street under observation, and from the sanding it receives to reduce slipperiness, but there is also a large amount of dirt from adjoining streets transferred by the wheels of vehicles; and in any wide-jointed paving, such as granite setts, it is surprising what an amount of mud may be retained in the joints after the surface has been as effectually cleaned as ordinary processes can make it; for as soon as traffic begins to run over a road just swept, horses' feet and wheels at once begin to disturb the mud from the joints, and it soon appears as if nothing had been done to clear it.

Cost of Cleaning. Macadam must head the list as the most costly for cleansing; next to that granite paving must be placed. Very close after this comes soft wood, the disintegration of which is very rapid, and the spongy nature of its surface assists to accumulate mud. Hard wood-paving can be placed at a considerable distance below soft wood, for if paved with close joints its surface is almost impervious, and it is easily cleaned. The road material costing the least for cleaning is asphalt.

Value of Road Materials. For years past endeavours have been made by various processes to determine the relative values of road-stones, and with more or less success. We have now under everyday traffic conditions, and upon a reasonably large scale, tests from which it is hoped accurate conclusions may be reached. The Road Board, in co-operation with several local authorities, have arranged for many different kinds of materials to be laid under identical circumstances supporting the same intensity of traffic.

In Kent, and within ten miles of London Bridge, a length of about 1½ miles of the London-Folkestone road has been divided into 23 sections, each representing about 1000 superficial yards, and upon these materials ranging in price from 1s. 9d. to 9s. 3d. per square yard have been laid. The first four sections were laid by the Kent County Council, the remaining 19 sections being given to contractors.

Materials in the Road Board's Test. The materials under test are as follow: Ordinary water-bound granite, the same (tar painted), single pitch grouting, double pitch grouting, Durax armouring, Kentish ragstone, tarred macadam, bitumenous macadam, granite grouted with Tarvia, asphalt macadam, natural asphalt matrix, slag tar macadam (single and double thickness), Plascom, Cormastik, Tarmac, Roadoleum, Roemac, Roadamant, Tarviated macadam, Lithomac, Pitchmac, Trinidad Lake asphalt (3 and 4 inches thick).

In each section, sockets are fixed on concrete bases, and measuring apparatus has been designed which fits in these, and by which means wear will be capable of measurement to the minutest part of an inch. Periodically, the wear will be measured and carefully plotted upon large-scale diagrams. Traffic statistics will be taken bi-monthly, and reduced to a denominator of tons per yard width of surface per annum. The traffic upon this section of road is heavy, representing upwards of 150,000 tons per yard width per annum, and including a frequent motor-omnibus service.

Cost of Maintenance. It is well known that our highways were the foundations and nursery for developing the mechanical traffic which has entered into a stage of prosperous commercialism, and is now creating an enormous burden upon the local ratepayer without equal contributory advantage; and thus it appears a great misfortune that legislation should have limited the powers of the Road Board to contributing "towards" the cost of "improvements" and not maintenance. The Road Board's income being derived from the tax on fuel, and mechanical traffic developed from that fuel being a serious addition to the expense of maintenance, it appears only reasonable that legislation should empower a contribution towards such expense.

Some interesting proposals in regard to road construction and maintenance were recently made by Colonel Crompton, consulting engineer to the Road Board, who said it seemed to him that in future road-construction schemes would have to be carried out in much the same fashion as railways were built. A class of contractors would have to be encouraged who would be responsible for local schemes. The mode of construction of highways would have to be reconsidered. It would be necessary to consider schemes to deal with great lengths at a time. He believed the present high prices of road-construction to meet omnibus traffic were due to the short lengths undertaken. The modern road surveyor would find himself able to deal with certain constructing firms and to give contracts out not only for construction, but for maintenance, as had been done not only in England but abroad. He believed there was a great opening for engineers and machinery in this direction, and that in a few years' time highways would show as great a development as railways.

A. TAYLOR ALLEN

Table showing the comparative cost, life, and maintenance charge of road surfacing

Description of Material	Average Life. Years	First cost per sq. yd.	Maintenance per sq. yd. per ann.	Cleaning per sq. yd. per annum
		s. d. s. d.	s. d. s. d.	d. d.
Water-consolidated macadam	2 to 3	3 6 to 5 0	0 3 to 0 9	1 to 4
Tar macadam (on existing foundation) ..	6	2 0 to 3 0	0 1 to 0 3	1
Asphalt (compressed).. ..	15 to 18	15 0 to 18 0	1 0 to 1 6	1 to 2
Hard-wood ..	15 to 16	13 0 to 16 0	1 0 to 1 3	1 to 2
Soft-wood	12	9 0 to 11 0	1 2 to 1 6	2 to 3
Sett paving ..	20 to 25	15 0 to 17 0	0 5 to 0 9	2 to 3

A Further Study of the Prose-writers from Roger Ascham to John Dryden. Examples of their Styles.

THE SHAPING OF ENGLISH PROSE

Roger Ascham. As our Anglo-Saxon forebears fought against the influences of Norman-French, so ROGER ASCHAM (b. 1515; d. 1568), the tutor of Queen Elizabeth, reflected the native English spirit in his strong masculine prose and his antagonism to the "Italianate Englishman," who modelled his conduct and his studies on what he or others brought back from Italy in those early days of Continental intercourse and travel. Ascham was devoted to the old English pastime of archery, and wrote a defence of it in English—"Toxophilus"—which he dedicated to Henry VIII., adding an address to the gentlemen and yeomen of England in which occurs a passage that forms at once an apology for and a defence of his native tongue: "As for the Latin or Greek tongue, everything is so excellently done in them that none can do better; in the English tongue, on the contrary, everything is in a manner so meanly, both for the matter and handling, that no man can do worse." Then follows the remark: "He that will write well in any tongue must follow this counsel of Aristotle, to speak as the common people do, to think as wise men do." There are several important works on education which belong to the sixteenth century, but Ascham's "Scholemaster" is the first in point of time, and contains not a little advice the value of which is of a permanent character. One of the truths that he urges is being propagated in our own day with all the energy of our twentieth century reformers: namely, the need of awakening in the mind of the pupil an interest in his work. In this connection the appended extract from the "Toxophilus" will be of interest to the reader:

The Wisdom of Ascham. "If men would go about matters which they should do and be fit for, and not such things which wilfully they desire, and yet be unfit for, verily greater matters in the commonwealth than shooting should be in better case than they be. . . . This perverse judgment of men hindereth nothing so much as learning, because commonly those that be unfitted for learning be chiefly set to learning. As if a man nowadays have two sons, the one impotent, weak, sickly, lisping, stuttering, and stammering, or having any mis-shape in his body, what does the father of such one commonly say? This boy is fit for nothing else but to set to learning and make a priest of. . . . Fathers in old time, among the noble Persians, might not do with their children as they thought good, but as the judgment of the commonwealth thought best. This fault of fathers bringeth many a blot with it, to the great deformity of the commonwealth. . . . This fault, and many such like, might be soon wiped away if fathers would bestow their children always on that thing whereunto nature hath ordained them most apt and fit. For if youth be grafted straight and not awry, the whole commonwealth will flourish thereafter."

Henry VIII., who encouraged Ascham, must have it placed to his credit also that he gave similar aid to Sir THOMAS ELYOT (b. about 1490; d. 1546), who wrote on behalf of good government, and translated Plutarch "On the Education of Children."

The Bible and English Literature. As poetry, in a chronological sense, takes precedence of prose in the history of English literature, so religious works precede secular in influencing the growth of English prose. We may not pause to consider this subject at any length; but the services of the early translators of the Bible cannot be overestimated. First among these translators was JOHN WYCLIFFE (b. 1325?; d. 1384). Here it is important to remember, however, that neither the "Wycliffe Bible" nor any of its successors was the work of one man, although "Wycliffe's Bible," "Tyndale's Bible" and "Coverdale's Bible" are common terms. The Gospels are the only part of the "Wycliffe Bible" certainly written by the great Reformer himself. Before Wycliffe's time only portions of the Scriptures had been translated into English. Wycliffe—to follow the accepted story—set himself a few years before his death, in 1384, to the task of producing the first complete English Bible. By 1382 he had completed the New Testament. His friend Nicholas, of Hereford, translated most of the Old Testament and the Apocrypha. John Purvey, a pupil of the Reformer, revised the work four years after Wycliffe's death. The translation (or paraphrase), which was made from the Vulgate (or Latin version), was originally issued in manuscript form; of this 150 copies are still extant. Written as it was for the common people, it is remarkable to find with how much ease "Wycliffe's Bible" can still be read. Wycliffe was a Yorkshireman, and we are told that when, a few years ago, several long passages were read to a congregation in his native county, not only were they understood by the hearers, but almost every word was found to be still in use.

William Tyndale. The work of Wycliffe was carried on and improved by WILLIAM TYNDALE (b. 1484?; d. 1536), a pupil of Erasmus, the great co-worker with Martin Luther in the Reformation. When Erasmus published his Latin version of the New Testament in 1516, he declared his wish that even the weakest woman should read the Gospels. "I long," he said, "that the husbandman

should sing portions of them as he follows the plough, that the weaver should hum them to the tune of his shuttle, that the traveller should beguile with their stories the tedium of his journey." Tyndale declared: "If God spare me I will one day make the boy that drives the plough to know more of the Scriptures than the Pope of Rome." Tyndale, who was a good Greek scholar, studied Hebrew for the purpose in hand, and while consulting the Vulgate went back to the originals as the basis of his version. He was helped in his task by a fugitive friar named Roy and others. It was "Tyndale's Bible" which, revised by MILES COVERDALE (b. 1488; d. 1568)—the first complete printed English Bible—and edited and re-edited as "Cromwell's Bible" (1539), and "Cranmer's Bible," or "The Great Bible" (1540), was set up in every parish church in England, in some cases being chained to the lecterns, or reading desks.

The Influence of the Bible. To quote Dr. Stopford Brooke, "It got north into Scotland and made the Lowland English more like the London English. It passed over to the Protestant settlements in Ireland." After its revision in 1611—there had been printed meanwhile the "Genevan Bible," a work handier in size than its predecessors, in Roman type and with the text divided into verses—it went as the Authorised Version with the Puritan Fathers to New England and fixed the standard of English in America. "Many millions of people now speak the English of Tyndale's Bible, and there is no book which has had, through the 'authorised' version, so great an influence on the style of English literature and the standard of English prose." In Edward VI's reign THOMAS CRANMER (b 1489; d. 1556) edited the English Prayer Book (1549-52). "Its English," Dr. Stopford Brooke notes, "is a good deal mixed with Latin words, and its style is sometimes weak or heavy, but on the whole it is a fine example of stately prose. It also steadied our speech." To tell the influence of the Bible on English writers from Shakespeare's time to Swinburne's would be to specify nearly all the best work of our greatest writers. Need we therefore urge its study upon our readers, when scarce any writer of note but has either acknowledged its inspiration or shown trace of it in his work? Too much stress cannot be laid upon the need—apart from all religious considerations—of Bible-reading on the lines laid down by Richard Moulton in that admirable work "The Literary Study of the Bible."

Theology and Philosophy. The development of English rhetoric and English philosophic thought between the close of the fifteenth and the earlier part of the eighteenth century may be studied in the writings of HUGH LATIMER (b. 1485?; d. 1555), Bishop of Worcester, whose sermons well sustain the homely and direct character of his native tongue; JOHN KNOX (b. 1505; d. 1572), the Scottish reformer and historian; JOHN FOXE (b. 1516; d. 1587), whose "Actes and Monuments," commonly known as "Foxe's Book of Martyrs," "gave to the people of all over England a book which, by its simple style, the ease of its story-telling, and its popular charm, made the very peasants who heard it read feel what is meant by literature"; JOHN JEWEL (b. 1522; d. 1571), Bishop of Salisbury, a learned Protestant controversialist; RICHARD HOOKER (b. 1554 ?; d. 1600), author of "The Laws of Ecclesiasticall Politie," a great theologian whose memory is enshrined in "Walton's Lives," and whose character is fitly indicated on his monument at Bishopsbourne, Kent, as "judicious"; WILLIAM CHILLINGWORTH (b. 1602; d. 1644), a notable anti-Romanist; JOSEPH HALL (b. 1574; d. 1656), Bishop of Exeter and Norwich, one of the first of English satirists; JEREMY TAYLOR (b. 1613; d. 1667), Bishop of Down and Connor, the author of "Holy Living" and "Holy Dying," and a voluminous writer who, in the words of his friend Bishop Rust, of Dromore, "had the good humour of a gentleman, the eloquence of an orator, the fancy of a poet, the acuteness of a schoolman, the profoundness of a philosopher, the wisdom of a chancellor, the reason of an angel, and the piety of a saint"; THOMAS HOBBES (b. 1588; d. 1679), a philosopher who applied the principles of geometry to the judgment of human conduct, and who, in his "Leviathan," "De Cive," "Human Nature," and other works, showed himself to be "the first of all our prose writers whose style may be said to be uniform and correct and adapted carefully to the subjects on which he wrote"; THOMAS FULLER (b. 1608; d. 1661), the style of whose best-known work, "Worthies of England," shows admirable narrative faculty, "with a nervous brevity and point almost new to English, and a homely directness ever shrewd and never vulgar"; SIR THOMAS BROWNE (b. 1605; d. 1682), a Norwich physician and author of "Religio Medici," than whom, according to Mr. Edmund Gosse, "among English prose writers of the highest merit there are few who have more consciously, more successfully, aimed at the translation of temperament by style," and who "unquestionably tasted the divine pleasure of writing for its own sake"; JOHN BUNYAN (b. 1628; d. 1688), author of "The Pilgrim's Progress," a work as famous as "Robinson Crusoe," as fascinating in a narrative sense, and of perennial influence on the religious thought of the young of all nations; ISAAC BARROW (b. 1630; d. 1677), another eloquent preacher and controversialist (note especially his treatise on "The Pope's Supremacy"), and as a mathematician worthy to stand near his pupil ISAAC NEWTON (b. 1642; d. 1727): RICHARD BAXTER (b. 1615; d. 1691), whose life may be studied as an example of self-help by the side of Bunyan's, and the style of whose many writings "is one of the finest specimens of direct masculine English, and a model for all who wish to talk to people instead of at them"; JOHN TILLOTSON (b. 1630; d. 1694), perhaps the only primate who took first rank in his day as a preacher, but who "probably presents more examples than any other author of passages wherewith to exercise the skill of the student of English composition in weeding out their

superfluous words and phrases"; JOHN LOCKE (b. 1632; d. 1704), author of "Two Treatises of Government," "An Essay concerning Toleration," "An Essay Concerning Human Understanding," a work especially to be commended to students on "The Conduct of the Understanding," and a philosopher who is spoken of as "the unquestioned founder of the analytic philosophy of mind"; and GILBERT BURNET (b. 1643; d. 1715), Bishop of Salisbury, and author of a "History of the Reformation" and a "History of My Own Times."

Regarded in this brief summary, the works of these theological writers may appear uninviting; but the general reader no less than the student cannot neglect them all without missing a fruitful part of the great and rich field of our national literature. Foxe's "Book of Martyrs," Taylor's "Holy Living" and "Holy Dying," Hobbes's "Leviathan," Fuller's "Worthies," Browne's "Religio Medici," Bunyan's "Pilgrim's Progress" and "The Holy War," Locke's "Human Understanding"—these especially, and others that we have named, are works of which every one who aspires to a sound appreciation of our literature should have first-hand knowledge; and just as we in early youth read Bunyan for the sheer pleasure of his narrative, so in manhood we may read the other religious and philosophical writers for their charm of style, their wisdom and humanity.

Prose of the Poets and Historians. Both Spenser and Shakespeare wrote prose. Spenser's "View of the Present State of Ireland" is written in a most pleasing style. Shakespeare's prose has been the theme of many commentators; see, for example, the admirable little manual of the late George L. Craik. The student is recommended to study the "men in buckram" section of "Henry IV." The "Arcadia" and the "Defense of Poesie" of Sir Philip Sidney (b. 1554; d. 1586) are also to be studied in this connection. The first popular English history in the language is "The History of England to the Time of Edward III." of the poet SAMUEL DANIEL (b. 1562; d. 1619). After Daniel's work may be considered the "History of the World," written in the Tower by SIR WALTER RALEIGH (b. 1552; d. 1618), and to be read for its human and personal interest more than on account of its intrinsic value as history. EDWARD HYDE, first Earl of Clarendon (b. 1609; d. 1674), friend of poets like Jonson and Waller, wrote a "History of the Rebellion." This was modelled on the style of the Roman historian Tacitus, and is specially notable for its biographical value. The "Life of Colonel Hutchinson," the Puritan, by his widow, LUCY HUTCHINSON (b. 1620), is one of the most delightful of biographies with a historical character for subject, and taken up as a study will be read through for the charm and simplicity of the narrative. To the domain of history and antiquarian study belong the writings of WILLIAM CAMDEN (b. 1551; d. 1623), JOHN SELDEN (b. 1584; d. 1654), JOHN STOW (b. 1525? ; d. 1605), RAPHAEL HOLINSHED (b. about 1580), and WILLIAM HARRISON (b. 1534; d. 1593). Mention must also be made here of the invaluable Diaries of SAMUEL PEPYS (b. 1633; d. 1703) and JOHN EVELYN (b. 1620; d. 1706), and the Letters and other writings of JAMES HOWELL (b. 1594; d. 1666), and the exquisite epistles of DOROTHY OSBORNE (b. 1627; d. 1695), afterwards the wife of Sir WILLIAM TEMPLE (b. 1628; d. 1699), diplomatist and essayist.

The Beginning of the Essay. The meaning of the word essay is "a testing." As we understand it to-day, an essay is a valuation of a subject, usually of a literary or social nature, from the standpoint of the writer. The "Essays of Montaigne," the translation of which by JOHN FLORIO (b. 1553; d. 1625) preserves for us a vigorous and perennially delightful example of Elizabethan prose, hardly come within the limits of the essay as we understand the word. Shakespeare was evidently familiar with his Florio as he knew the translation of Plutarch's "Lives" by Sir THOMAS NORTH (b. 1535; d. 1601). The Elizabethan and Jacobean pamphlets were, in a sense, essays, but we see in them perhaps more distinctly the beginning of the modern newspaper, because they were published for controversial purposes. They form in themselves a somewhat absorbing branch of literary and historical study. A number of the writers of these pamphlets also wrote tales, so that while the "Euphues" of LYLY [see LITERATURE, page 594] is generally regarded as the earliest English novel, it is not quite isolated as an example of English prose narrative. Even if we leave Sidney's "Arcadia" out of the question, there are the tales as well as the pamphlets of ROBERT GREENE [see page 679]; THOMAS LODGE (b. 1558; d. 1625), whose "Rosalynde" inspired Shakespeare's "As you Like It"; and THOMAS NASH (b. 1567; d. 1601), whose "Jack Wilton" provided the prototype of Falstaff. Londoners who desire to learn how their predecessors lived three centuries ago will find a world of entertainment in "The Gull's Hornbook" of THOMAS DEKKER (b. 1570; d. 1637?). The more permanently interesting of all the pamphlets is the "Areopagitica," a trenchant plea for the liberty of the printing press, by JOHN MILTON (b. 1608; d. 1674).

The First English Essayist. The first of the English essayists is FRANCIS BACON (b. 1560; d. 1626). The student can have no better guide than is provided in the fiftieth of Bacon's "Essays"—the one entitled "Of Studies." We quote part of this as exemplifying Bacon's method and perspicuity of style:

"Studies serve for Delight, for Ornament, and for Ability. Their Chiefe Use for Delight, is in Privatenesse and Retiring; For Ornament, is in Discourse; And for Ability is in the Iudgement and Disposition of Businesse. For Expert Men can Execute, and perhaps Iudge of particulars, one by one. But the generall Counsels, and the Plots, and Marshalling of Affaires, come best from those that are *Learned.* To spend too much Time in *Studies,* is Sloth; To use them too much for Ornament, is Affectation; to

make Iudgement wholly by their Rules is the Humour of a Scholler. They perfect Nature, and are perfected by Experience: For Naturall Abilities, are like Naturall Plants, that need Proyning by *Study:* And *Studies* themselves, doe give forth Directions too much at Large, except they be bounded in by experience. . . . Reade not to Contradict, and Confute; Nor to Beleeve and Take for granted; Nor to find Talke and Discourse; But to weigh and Consider. Some Bookes are to be Tasted, others to be Swallowed, and Some Few to be Chewed and Digested. That is, some *Bookes* are to be read onely in Parts; Others to be read but not Curiously; And some Few to be read wholly, and with Diligence and Attention. . . . Reading maketh a Full Man; Conference a Ready Man; and Writing an Exact Man. . . . *Histories* make Men Wise; *Poets* Witty; *The Mathematiks* Subtill; *Naturell Philosophy* deepe; *Morall* Grave; *Logick* and *Rhetorick* Able to Contend."

The Prose of Ben Jonson. Of Bacon's Essays Hallam rightly declared that it "would be derogatory to any educated man to be unacquainted with them." Next to them we should place the "Discoveries" of BEN JONSON [see LITERATURE, pages 854-5], which Mr. Swinburne prefers before Bacon's Essays and Mr. Saintsbury describes as coming "in character as in time midway between Hooker and Dryden." Jonson's "Discoveries" have been too long neglected. A recent writer acutely says: "A comparison of the vocabulary of Sir Philip Sidney's 'Defense of Poesie' with that of the 'Discoveries,' written nearly sixty years later, will disclose a far larger number of words demanding explanation in the latter. On the other hand, a like comparison between the two works with reference to the structure of sentence and paragraph will exhibit a form and symmetry, a sense of order and proportion, and a consciousness of the demands of literary presentment in the 'Discoveries' for which we may look in vain in the somewhat loosely-strung periods and formless paragraphs of the 'Defense.' This contrast, as Prof. Schelling, the first adequately to edit the 'Discoveries,' points out, becomes the more startling when we remember that Sidney's work is characterised by a logical sequence and continuity of thought, and that Jonson's is more or less of a commonplace book containing, as he himself says, 'discoveries' made upon men and matter, as they flowed out of his daily readings, or had their reflux to his peculiar notions of the times." Here is a brief extract from Jonson's tribute to the eloquence of Bacon. It is largely an adaptation from Seneca on an Augustan orator:

Ben Jonson's Praise of Bacon. "There happened in my time one noble speaker who was full of gravity in his speaking; his language, where he could spare or pass by a jest, was nobly censorious. No man ever spoke more neatly, more presly (concisely), more weightily, or suffered less emptiness, less idleness, in what he uttered. No member of his speech but consisted of his own graces. His hearers could not cough or look aside from him, without loss. He commanded where he spoke, and had his judges angry and pleased at his devotion (disposal). No man had their affections more in his power. The fear of every man that heard him was lest he should make an end."

Lowell has applied this passage to Emerson. There is a great deal in Jonson's "Discoveries" concerning education and study that will generously reward the most careful attention. After Jonson, considered as an essayist, come ABRAHAM COWLEY (b. 1618; d. 1667), whose language is at once simple and graceful, and SIR WILLIAM TEMPLE (b. 1628; d. 1699), distinctly a predecessor of Addison.

It is difficult to classify the "Anatomy of Melancholy" of ROBERT BURTON (b. 1577; d. 1640), but Johnson greatly admired it, and it is full of quaint and curious learning. The "Microcosmographie" of JOHN EARLE, Bishop of Salisbury (b. 1601; d. 1665), is at once of social and philosophical value, but stands, like the "Anatomy," by itself. Three other books that demand notice are the "Lives" and "Compleat Angler" of IZAAK WALTON (b. 1593; d. 1683), the first a gem of literary biography, the second one of the first of "country books"; and the "Autobiography" of LORD HERBERT of CHERBURY (b. 1581; d. 1648), which Mr. Swinburne has placed among "the hundred best books."

Criticism. The place of honour as the first of English critics belongs to JOHN DRYDEN [see LITERATURE, pages 976-7]. In the words of Lowell, Dryden, more than any other single writer, contributed, as well by precept as example, to free English prose from "the cloister of pedantry," and by his masterly handling to give it "suppleness of movement and the easier air of the modern world."

"His style," Lowell continues, "has the familiar dignity so hard to attain, perhaps unattainable except by one who feels that his own position is assured. Swift was as idiomatic, but not so elevated; Burke more splendid, but not so equally luminous. That his style was no easy acquisition, though, of course, the aptitude was innate, he himself tells us, when he tells us that the Court, the College, and the Town must be joined in the perfect knowledge of a tongue. 'The proprieties and delicacies of the English are known to few; it is impossible for a good wit to understand and practise them without the help of a liberal education, long reading, and digesting of those few good authors we have amongst us, the knowledge of men and manners, the freedom of habitudes and conversation with the best company of both sexes, and, in short, without wearing off the rust which he contracted while he was laying a stock of learning.'"

The introductions to Dryden's works are specially worthy of study. The famous "Essay on Dramatic Poesy" has already been commended. Nearly the whole of Dryden's criticisms will be found edited by Prof. W. P. Ker in his "Essays of John Dryden."

J. A. HAMMERTON

The Poor Law Service as a Career. Doctors and Nurses in Hospitals and Asylums.

POOR LAW DOCTORS AND NURSES

With a single exception, our survey of the municipal service is now complete. Hitherto we have been concerned mainly with the general duties of local government. We have now to consider the machinery that exists throughout the country for maintaining the destitute poor, and for tending the sick and insane among them. This work is performed, for the most part, by local boards of guardians, but the maintenance of hospitals and asylums for the poor is often entrusted to special and more powerful authorities, in which the Poor Law guardians are duly represented. The boards of guardians have no direct relation with county or borough councils, and are entrusted with no such general powers. They are elective bodies of a quite special class, charged with only a single function—the administration of Poor Law relief.

The guardians of the poor, indeed, are the unpaid official almoners of the nation's charitable doles to those of its population whom adverse conditions prevent from supporting themselves. Under the strict direction of the Local Government Board, the funds raised for this purpose by means of the Poor Rate are administered by the guardians through the agency of a large staff of officers of various grades.

Indoor and Out Relief. The help thus rendered to the poor is of two classes. Outdoor relief, in the form of weekly grants of money, food, firing, and free medical aid, is sometimes granted in cases of temporary want, and is also given under certain conditions to enable the widowed, aged, and infirm to keep the grim wolf Hunger from their doors. For the rest of the sad army of poverty there is the system of indoor relief, comprising various institutions in which the destitute are housed and cared for. In addition to the workhouses, they include cottage homes and schools for the children, infirmaries for the sick, asylums for the insane, and casual wards as purely temporary shelters. This main distinction between indoor and outdoor relief runs through all Poor Law matters; and, as we shall see, it affords a convenient means of classifying the various members of the staff employed by the guardans.

The Problem of Relief. The developments of the past few years have awakened unusual interest in the problems of pauperism, and every thoughtful reader must have reflected on the grave responsibilities with which the guardians of the poor are entrusted, and the heavy cost of the pauper to the State. The growth of the Poor Rate, the classification of workhouse inmates, Poor Law labour colonies, the treatment of tramps, the wisdom or unwisdom of extensive out-relief—such aspects of this great national question are constantly under debate in the public Press. To discuss them here would be idle. But it will help us to grasp the great importance of the Poor Law service if we consider the latest official returns of pauperism.

These show 298,877 indoor and 499,020 outdoor cases receiving relief in England and Wales, which gives a total of 797,897 persons (including approximately a quarter of a million children) maintained at the public expense. During the last recorded year their cost amounted to over fifteen millions sterling!

The Service as a Career. Let us turn from more general considerations to discuss the aspect of the Poor Law service in which we are specially interested—namely, the prospects it affords as a career.

Excepting always the medical and nursing section, it must be admitted that the inducements to engage in this branch of municipal work, for men and women of real ability and ambition, are somewhat scanty. The service, as a whole, suffers from lack of organisation and system. There are no education tests prescribed for candidates on entrance, and few suitable qualifications by means of which an energetic subordinate officer may demonstrate his fitness for advancement. Many efficient officers remain for weary years, not only without promotion, but without even the smallest advance of salary to reward ability or encourage endeavour. Further, while posts of distinctly inferior grade are properly remunerated, there are few appointments of intermediate worth, and still fewer really valuable prizes. The popular outcry against the burden of the Poor Rate tends to keep stipends small; and the general level of salaries for clerical and executive work under the guardians is certainly lower than that prevailing under the local councils.

An Expert's Views. In connection with this matter, it should be mentioned that a powerful voluntary organisation exists in the service, under the title of the National Poor Law Officers' Association, for the dual purpose of increasing the efficiency of officials and of improving their status. A former President, Dr. James Milward, of Cardiff, has expressed himself so justly and wisely on the prospects of the Poor Law service that his remarks are worthy of quotation.

"It will, I think, readily be admitted," said Dr. Milward, "by most people who have had much practical experience of the Poor Law, that its great fault is that it stands almost or quite alone among the branches of the public service in not providing a career for its members. In our Civil Service generally the prospect of

promotion is active in stimulating the official to do his duty—and a little more. Unfortunately, here there is no such motive. No matter how able, zealous, or efficient an officer may be, he rarely passes from one grade to a higher. There are no prizes in his profession."

Uninviting Prospects. That the state of things thus sketched calls for an effective remodelling of the Poor Law system is hardly to be denied. The aims of the Association in the direction of reform are thus summarised by the authority already quoted: "We have still before us the two great problems of the training and promotion of officers, with all that those problems involve. First comes the question of the examination of the candidates for the various branches of the service. Instead of adult applicants for posts relying on their own persuasive powers or the influence of friends, they should qualify themselves, as in other branches of the public service, by examination when young; and, entering the service at the bottom, should learn their business in subordinate offices, and rise according to their abilities, with salaries graduated according to their posts and the length of their service."

There are indications that some such reorganisation as is here depicted may be expected in the future, though it is as yet too early to attempt a precise forecast. The powerful Royal Commission on the Poor Law, which issued its report in 1909, made sweeping recommendations for remodelling the whole system of relief, and for placing the Poor Law service on a more satisfactory footing. And though experts regard it as unlikely that any such complete reorganisation will be effected by statute for some years to come, improvements in the service are constantly being effected meanwhile by means of Local Government Board orders. Further, a Poor Law Examinations Board, constituted in 1910, holds examinations annually for relieving officers and for workhouse officers. In this way the Board has laid the foundations of a new and important system; the value of its certificates is becoming more widely recognised every year, and ultimately these tests may become compulsory for the higher branches of the Poor Law service.

Humanising the Poor Law. Prospective candidates must not overlook the fact that an officer of the guardians works under conditions which to a sensitive nature are depressing or painful. He is brought into daily contact with the direst poverty, and all its attendant miseries of dirt, disease, and vice. To a humane public servant, however, this very circumstance gives his work among the obscure poor its greatest dignity and worth. It offers countless occasions for helping the helpless and befriending those who sorely need a friend. In the case of applicants for relief or maintenance, the relieving officer is charged with the duty of fully investigating their circumstances and character before their request is submitted; and, in deciding the nature and extent of the aid to be offered, the board is necessarily guided in the main by that official's report. Similarly, the fortunes of the appeals of workhouse inmates for special leave in search of work, indulgences in the matter of diet, and other privileges are largely determined by the views of the guardians' clerk and the master or matron of the house. These instances will show what responsibility and power the Poor Law officer possesses, and what scope his work affords for patience, conscientiousness, and humanity. In this connection it is noteworthy that a leading municipal authority, whose opinion the present writer sought as to the most useful branch of Local Government work, replied as follows: "For a career of sheer usefulness and service, as distinguished from high monetary reward, I regard the administration of the Poor Law as foremost, and would specially mention the valuable work of the nurses in our infirmaries and hospitals for the pauper classes."

How we have Improved. How vastly official methods of treating pauperism have progressed since the days when the "sturdy beggar" was whipped, branded, and enslaved, readers will scarcely need to be reminded. The records of Exeter workhouse show that two centuries ago the task of "performing cures on wounds and sores" on the hapless inmates was entrusted to the tender mercies of—the beadle! The strides made during even the last fifty years or so toward a humaner method can best be realised, perhaps, by comparing a modern workhouse with that described in "Oliver Twist." Yet much still remains for individual effort to accomplish in the humanising of the Poor Law.

A single instance, selected almost haphazard from among many such, will serve to illustrate the possibilities of kindly service awaiting the humane official. The introduction into Hull workhouse of the "Brabazon" system of skilled work, which has added a new pleasure and interest in life to many of the unhappy inmates, was due in the first instance to the consideration of the master and matron. To be able to soften in ways like this the operation of a Poor Law system, which in itself is apt to be hard and grim, is a prospect which might have tempted St. Francis of Assisi to become a guardians' officer.

Service Pensions. Under the Superannuation Act of 1896, servants of the guardians, in return for a deduction which in the case of new appointments is two per cent. of their pay, are entitled to resign on two-thirds salary after forty years' service, or on a smaller proportion if invalided earlier. Female nurses and attendants may join the scheme or not, as they please, but with all other officers the system is compulsory.

Hospitals and Asylums. The Poor Law infirmary or hospital is on practically the same footing, in respect of its administration, as the asylum for pauper lunatics and imbeciles. These two classes of institution may therefore be considered together. In discussing them we may adopt the convenient method (already followed more than once in this course) of

selecting a leading and typical authority and commenting on such differences in the conditions of employment as distinguish it from less important bodies.

Metropolitan Asylums Board. In its Poor Law administration, as in so much else, London affords us the most striking instance of this class. The Metropolitan Asylums Board, popularly known as the "M.A.B.," was created by the Metropolitan Poor Act of 1867 to furnish proper provision for the imbecile poor, and for others who were stricken with fever or smallpox. It now owns 10 great fever hospitals, 3 others for smallpox, a motor and steamship ambulance service for the removal of patients, 6 institutions for the mentally defective, 2 large hospitals and 5 schools and homes for sick children, a training ship for boys, the 21 metropolitan casual wards, and 2 sanatoria for consumptives under the National Insurance Act. These are controlled by 73 managers, 55 of whom are elected by the London boards of guardians, the remainder being nominated by the Local Government Board.

Through the courtesy of the clerk, Mr. T. Duncombe Mann, we are furnished with authoritative particulars as to the staff of this great Poor Law association. In respect of medical appointments, the following details are given:

A SCENE IN A WORKHOUSE INFIRMARY

Infectious Hospitals. There are 11 medical superintendents at £400 a year, rising £25 annually to £700, all with unfurnished houses, and some receiving extra remuneration for acting as clinical instructors to medical students. These officers are in supreme control, and their duties are therefore very wide-reaching. About 50 assistant medical officers are employed in two grades. Those in Class I receive £280 the first year, and afterwards £300 per annum; while for Class II the scale of pay is £180, rising £20 annually to £240—all with board, lodging, and washing. Among the assistant officers about fourteen vacancies occur every year.

Imbecile Asylums. Medical superintendents receive £600, rising £50 yearly to £800, with unfurnished houses. Their staff of 14 medical assistants comprises three classes of appointment. The scale of pay in the first class is £300 to £360; in the second, £210 to £250; and in the third, £180 to £200. All assistants receive board, lodging, and washing in addition to their pay.

The medical officers of workhouse infirmaries are less liberally remunerated. Where several resident doctors are required—as in the larger London unions—the senior officer may receive between £350 and £450 a year, and his assistants from £120 to £250 or £300, according to their grade. But there is no uniformity in the rates of pay offered by the guardians, and in country areas the scale is often lower.

District Medical Officer. In order to make complete our survey of medical appointments in the Poor Law service, it is necessary to refer to the district medical officer, better known among his patients as the "parish doctor." This is a non-resident post, the local practitioner who holds it being required, in return for a fixed salary paid him by the guardians, to furnish the poor of his district with medical treatment and drugs. Extra fees are prescribed by the Local Government Board for certain operations, and there may be special charges made for childbirth cases, and for cod-liver oil and similar medicines supplied. The remuneration paid is never very considerable, varying from a purely nominal sum to £150 or so yearly. But many a struggling young medical man finds his sheet-anchor in the £80 or £100 a year he receives as parish doctor; and even more flourishing practitioners do not disdain such an addition to their incomes. This official, however, is now yielding ground to the "panel doctor"—the medical officer provided for insured persons by the National Insurance Act of 1911—and the earnings of the "parish doctor" will inevitably diminish still further in the future.

Matrons and Nurses. The responsible officer in charge of the nursing and household establishment in Poor Law hospitals and asylums is the matron. Her post is generally admitted to be an arduous and an anxious one. With or without the aid of an assistant, she is required to superintend the work of her staff of nurses, to train the probationers, and, while thus attending to the professional side of her duties, to secure the smooth working of the whole institution by

careful regard for a thousand domestic details. These duties need a qualified nurse who is also a capable, energetic organiser; and, well paid as she is, the matron fully earns her salary. In nursing institutions generally, her normal rate of pay as a resident officer is from £80 to £120 a year, and her assistant is rewarded at about half this rate.

Respecting the Metropolitan Asylums Board service, Mr. Mann writes: "The matrons of the Board's institutions must all be trained nurses; the pay varies from £120 to £150 a year, according to importance of position. In each case full resident allowances are granted. In the children's schools the matron is head of the institution, but in the asylums and hospitals is not, the medical superintendent being in charge. The whole number of matrons employed is about 25."

Nurses under the Asylums Board. The staff of nurses employed by the Metropolitan Asylums Board is a very large one; it varies considerably from time to time, but generally numbers about 1700 at the Board's hospitals and institutions for children. In addition, about 1000 nurses and male attendants are engaged for the mentally defective.

Assistant-matrons at all institutions are paid from £55 to £65 per annum. In the *infectious service* the following grades of nurses are employed: Sister (£38 to £44), who must have been trained; staff nurse (£26 to £34), who is required to have undergone a general or fever hospital training; assistant nurse, Class I. (£24 to £28), who must have had certain nursing experience, and must be twenty-three years old at least; assistant nurse, Class II. (£20 to £22), and probationer nurse (£18 to £20). For the last two classes no previous experience is necessary, but candidates must be twenty-one years of age. Probationers are trained for the profession, and on passing the necessary examinations are granted certificates. Assistant nurses may enter for the same examinations, and if they are successful they are promoted to staff nurses. A certain number of probationers, after two years' work, are transferred to the great London general hospitals to finish their training, the fever hospital experience counting as one year's general training. All nurses receive full residential allowances.

In the *children's service* the grades are: Head nurse, or home sister (£35 to £44); ward sister, or charge nurse (£34 to £38); staff nurse (£27 to £34); assistant nurse (£20 to £28), and probationer (£10 to £18).

Care of the Feeble-minded. *For the care of imbeciles and feeble-minded,* the posts are: Head nurse (£36 to £46); charge nurse (£30 to £36); deputy charge nurse (£29); nurse (£22 to £28), and female industrial trainer (£25 to £45). Ample recreation time and leave (annual and occasional) are granted to all nurses. Further particulars can be obtained from the Clerk to the Metropolitan Asylums Board, Victoria Embankment, E.C.

Another important authority, the London Asylums Committee, remunerates its nursing staff at the following rates, in addition to board, lodging, washing, and uniform: Head night nurse (£45 to £53); head day nurse (£45 to £50); special charge nurse (£38 to £42); first class nurse (£31 to £37); second class (£20 during probation, then £24 to £30). In each case the increment is £1 a year. While on probation, nurses are required to attend classes for instruction. Extra payments are made to those nurses who pass certain recognised examinations.

Confusion in the Nursing Service. The Poor Law nursing service, as a whole, exhibits no uniformity of system in respect of either salaries or qualifications.

Some boards of guardians require merely that applicants should have had a year's experience in a public institution, while others insist on two or three years' systematic training in a recognised hospital school; and those boards with a large hospital or infirmary under their control generally prefer to train their own staff as far as possible. For general infirmary duty, the Central Midwives' Board certificate in midwifery is a very valuable qualification.

For head or charge posts, the usual age limits are 25 and 35 or 40 years, and for assistants or probationers, 21 and 30. Fully trained and certificated nurses are paid from £32 to £45 as resident officers—or £65 to £85 if non-resident—according to the liberality or otherwise of the guardians and the importance and responsibility of the appointment. The initial salaries of those who are less highly qualified, or hold assistant rank, vary in the same way between £30 and £21, or occasionally as low a limit as £18, a year. The following are average figures for probationers: Two years' training, £12 and £16; three years', £10, £16, and £20. It is commonly stipulated that applicants for nursing posts must be either single women, or widows without children dependent on them.

Position of Poor Law Nurses. The position accorded to Poor Law nurses varies no less than their stipends. The Metropolitan Asylums Board is careful to provide each officer, as far as possible, with a room of her own, and expressly declares that "The nurses rank as a class superior to and separate from the other members of the female staff, and are boarded and lodged apart from the remainder of the hospital staff." But in small infirmaries these officials are sometimes far less punctiliously treated. In this respect, as in others, the service needs to be established on a uniform basis.

A brief reference may be made here to the attendants of either sex employed at Poor Law asylums and hospitals. The rates of pay and conditions of entrance very closely resemble those already given relative to the posts of labour master and mistress. Under the Metropolitan Asylums Board, male attendants on the feeble-minded receive from £32 to £115 a year, with full emoluments. For an attendant's position the qualifications most in request are good character and bearing, sound health, and physical strength.

ERNEST A. CARR

The Mechanical Theory of Life and its Negation by Bergson the Philosopher and Driesch the Experimental Biologist

LIFE IS MIND AND MIND IS LIFE

OUR way of looking at living beings is henceforth to be strictly evolutionary. Bergson, as we shall see, has imposed this necessity upon many evolutionists who have altogether forgotten their own great principle. In no other problem is this necessity so deep and so momentous as in that which is now before us. Until the last few years we have contentedly assumed, on the scientific plane, that the physiologists were right in declaring that all multi-cellular living beings are none other than associations of cells, which, by their association, make the organism. The most whole-hearted evolutionists, such as Sir Edward Schäfer, of Edinburgh, in his recent Presidential Address to the British Association, have imposed upon most of us a tremendous fallacy, just because they have failed to look at living beings in the evolutionary way, even when they most protested that they were doing so. Let us see what the issue is.

The Work of the Physiologists. The physiologists in general, including the great pioneers in the nineteenth century, and such distinguished representatives of the school as Sir Edward Schäfer, and Professor E. H. Starling, of University College, devote their lives and splendid powers to studying how the living creature works. That is what we mean by physiology. It is the study of function as distinguished from the complementary study of structure, which we call anatomy. Above all, such physiologists as we have named are concerned with the body of man, and their official duties are to teach medical students the normal working of the body prior to their study of its abnormal working in disease—the science of pathology. But no modern physiologist, nor any past physiologist worthy of the name, confines himself to the study of man. If he did, he would steadily fail.

Building up the Book of Life. All progress in the study of life has depended upon what we call the comparative method. Each form of life is, if we could fathom it, a key to all the rest. Each form of life offers to our reading some sentence or phrase or syllable or letter of the Book of Life which we are trying to decipher. Thus the physiologists, perhaps desiring to explain the action of a given gland in man, in relation especially to the hope that thus some obscure disease, such as diabetes, may be unravelled, will spend, it may be, twenty years in the study of not man, but the dog, while, in an adjoining institution, another physiologist is observing the behaviour of certain plants, not without hope that his results may contribute to our understanding of cancer.

Hence, the physiologists have been naturally led to generalise about the nature of living things; and the conclusions which they reach depend, as they must and should, upon the nature of the evidence before them. But what is that evidence? The physiologist studies the functions of, say, the liver, the pancreas, and the thyroid gland in man or any of the higher animals; or he studies the action of the heart and blood-vessels in the circulation of the blood. In the first case he discovers a long series of chemical facts, and in the second a wonderful mechanical apparatus of pumps, valves, and tubing; and he sees that these chemical and physical mechanisms serve the life of the living creature.

The Body as a Machine. Indeed, when he examines the body, whether of an animal or a plant matters not, the physiologist finds that it is a sort of immeasurably complex physico-chemical mechanical laboratory, made of a multitude of living cells of various kinds, arranged in tissues and organs, together with a good deal of lifeless material, which serves various mechanical functions, but which has been made by certain of these living cells. In this machine, as in those which man makes, the physiologist finds the repetition of certain orderly processes, such as the circulation of the blood, the phenomena of digestion, the respiratory circle, and so forth.

The resemblance and parallelism to, say, a motor-car is obvious and close. To compare the aeroplane and the lark is to marvel at the fundamental identities of mechanical principle which both display, each taking in mechanical energy in the form of food or petrol, each using it in what is really one and the same way, and producing the same chemical waste-products—water and carbonic-acid gas—in the process. The whole story of physiology consists of the recognition and elucidation of parallels of this kind. Some of them are mechanical, like questions of pumping and ventilation and locomotion; some of them are chemical, like those of nutrition and digestion and excretion, and so forth, but all belong to the physico-chemical order. Doubtless they are very complicated. But if we compare the working of the lark and the working of the aeroplane, this difference in complexity is all that we can admit.

The Chemical Theory of Life. Where the aeroplane does what is wanted by a simple process, such as the combustion of the petrol by an electric spark, the lark does the parallel thing by means of a long and still obscure series of chemical fermentations; and so in other cases. But mere degrees of complexity do not constitute differences of kind. A machine is still a machine, whether it be a child's toy or the engine of a Dreadnought: size and complexity do not affect the *nature* of the thing,

Hence the physiologists, looking at and for mechanism, and finding it, proclaim that physics and chemistry will give us the key to vital processes. As each year passed, and found them in the possession of some new light upon the details of these physico-chemical processes, they became more and more certain that, with time and patience, they would completely explain the living being as the physicist and chemist can completely explain, in all essentials, the working of a motor-car.

What is Life? It is clear, in the case of the motor-car or any not-living machine, that the machine *is made* by the assemblage and due co-ordination of its parts. Similarly, when we look at the lark or the oak or even a man—observe what awful consequences are about to follow—we may conclude that it is simply the association or assemblage of cells, tissues, organs of various kinds *that make the organism*, and any "mind" or "soul" it may possess. Apparently a multitude of cells, of happily adjusted kinds, have built themselves into an arrangement, with "physiological subdivision of labour," so that the living being is thus constituted.

Take these cells apart, and the living being ceases to exist, just as an aeroplane ceases to exist if all its parts are separated and scattered. Our notion of individuality, of ourselves as *Persons*, as single, indivisible entities—our ideas of the Self, of the Psyche or Soul—where are they now? Obviously they cannot stand. The idea of a living individual must be a myth. Any of us is only an individual in the sense that an aeroplane is an individual—because its parts work together. Really, with this long-dominant view, the body of a dog or a man is to be looked upon as a sort of colony, a kind of assemblage of a mighty host of really separate parts, whose working together, and that alone, constitutes the organism, and affords the illusion of an individual, a single being. And, of course, when this physico-chemical machine which we call the body is broken up, or wears out, and ceases to exist, the living being and its life cease also. In fact, life, so-called, is not a reality at all, but a name we give to the working of certain peculiar mechanisms, which differ from other machines only in that they have a different origin.

The Physiological Theory of Life. Thus the physiological, physico-chemical, mechanical, or materialistic theory of life. The fatal objection to it is nowhere revealed until the last sentence, with which we have purposely concluded our statement of it. For we have forgotten something—something which is not the business of the physiologist, and which he has ignored, basing his theory of life upon a very partial and inadequate survey of the *made machine* merely.

But the student of the history, the making, of the machine is interested not merely in the contents of the chemical retort, to use Bergson's phrase, but in the retort itself. We find what no one disputes, but what the physiologist has simply forgotten, that "this retort creates its own form through a unique series of acts that really constitute a history." And no explanation of life will satisfy us now that ignores this immeasurable difference between the lark and the aeroplane: the aeroplane was made by the putting together of pieces of material from without, *but the lark made itself from within.*

That is what we meant when we began by saying that we must make our point of view *evolutionary.* The physiologist looks at the working of the lark, and says it is a machine. A deeper science points to the evolution of the lark, and says: "What kind of *machine* is this, which constructs itself so exquisitely and efficiently from an invisible speck—a machine *not made with hands?*" It will not do to look *statically* at what is, and to discuss its working; we must also look *dynamically* at how it came to be, and must seek to interpret it as a product of that mighty stream which we call evolution.

Does the "Soul" Make the "Body"? With this resolve let us ask ourselves whether the physiologist is indeed stating the whole truth when he points to the structure of the organism out of many different kinds of cells, and to its functioning or working as the result of the interaction of those cells. Is he indeed right in maintaining that the cells make the so-called "individual" by their association, and that this individual is thus really nothing of the sort, and his ideas (if he be human) of the Self and the Personality and the Soul are illusions?

Or is it really the individual, the living being, that has made the cells by means of dissociating and specialising and equipping with organs the original powers with which it was endowed? Is it not really the living being that makes the body, rather than the body that makes the living being? For life and death, for now and hereafter, for religion and conduct, for everything that matters, this question is the most important that a man can ask and answer. Is the "soul" merely a product, or rather a by-product, of the body, or is the body a product of the soul? Does the structure make the function, which we call the life, or does the life and its functions make the structure? There is no escape from this question. It is the ultimate question of biology, if not of philosophy itself. Everything depends upon it; and if modern science has a different answer from that which called itself the verdict of science in the nineteenth century, we must certainly acquaint ourselves clearly and profoundly with it.

The Philosophical View. The poets and the philosophers, the saints and the seers, have never been in doubt. Edmund Spenser definitely answered, in the sixteenth century, this very question around which the greatest students of the twentieth are now assembled. In so many words, he said:

"Of the soul the body form doth take,
For soul is form, and doth the body make."

"It takes a soul to move a body," said Mrs. Browning, long afterwards; and the question is whether these poets were right who said, in set terms, that the soul makes and moves the body.

The mighty Frenchman Lamarck, the true founder of the doctrine of organic evolution, was as explicit as the poets in his answer to this question. Later we shall have to study this great man at length, for modern biology is returning to him by leaps and bounds. But, for the moment, we need only note that at the very root of the Lamarckian philosophy is the belief, the first principle, that *function precedes and creates structure.* Our own evolutionists were not all as clear thinkers when it came to ultimate problems as they supposed, but Herbert Spencer, who was incomparably the greatest mind among them, and who, alone, realised the greatness of Lamarck, is equally clear in asserting that, as the first fact of organic evolution, *function precedes structure.*

A Clue to the Answer. Indeed, we have only to look for ourselves in order to see one illustration of this truth. Of certain minute and simple animals, the rhizopods, "which present no distinction of parts, and nevertheless feed and grow and move about," Huxley said that they "exhibit life without organisation." The modern microscope and modern bio-chemistry know well that Huxley omitted a very important word. He should have said "*visible* organisation." Nevertheless, the fact remains that such creatures perform, before the evolution of many structures familiar to, and in, all of us, exactly those functions, as of nutrition and locomotion, which our stomachs and legs perform for us. In the history of life, therefore, function precedes structure; and Bergson is fully justified in saying, of the most important case of all, brain and mind, that "it would be as absurd to refuse consciousness to an animal because it has no brain as to declare it incapable of nourishing itself because it has no stomach. The truth is that the nervous system arises, like the other systems, from a division of labour. *It does not create the function*, but only brings it to a higher degree of intensity and precision." In a word, Life, which is Mind, made the brain, and not the brain the mind.

Finally, we come to the great fact of individual development, the history of the individual, which the physiologists ignore, because it is not their business, as they think. Indeed, it is their business, for what function can be so deeply worthy of study as the function of growth and development? The study of the mature "mechanical laboratory," which the body seems to be, and indeed is—though it is more—showed us how closely it may be compared to a lifeless machine, which is made, as engineers say, by "assembling" parts. We talk of evolution, and now we shall be judged by evolution—that is, by the *history* of the things we study. But, as Bergson profoundly says, "A mere glance at the development of an embryo shows that life goes to work in a very different way. *Life does not proceed by the association and addition of elements, but by dissociation and division.*"

Evolution Defined. "Evolution," we are always saying, and what does the word mean but unfolding? The formation of a living being is thus indeed an evolution, the unfolding, displaying, and material expression, in cell, tissue, and organ, of powers latent, not yet evolved, in the germ. This is the tremendous lesson of embryology, the science of embryos, or immature, not yet developed, organisms.

The Physiologists Routed. Now, at last, we are in a position to refute the theory which the physiologists imposed upon nearly all of us until the last few years. Their view that a man is merely a colony, and that any idea of the soul or personality is an illusion, must be abandoned. They had no more right to draw this inference from the multiplicity of cells and parts in the body than we would have to deny the individuality of the organist on account of the multiplicity of stops and keys and pipes in the organ. They are not entitled to declare that the soul is a myth, and the cells of the body have associated themselves to make the organism, for they are merely looking at the matter statically, at the machine as it stands, instead of evolutionally, at the machine in its becoming. The tremendous contribution of embryology to our problem is its demonstration that the organism makes itself from within. And what about the unity which we feel when we think of our*selves?* Can that be still maintained after physiology has shown that, for instance, the brain is simply an arrangement of millions of nerve-cells?

Indeed, it can be maintained, on strictly scientific grounds. We are to "think in evolution." That means that we are to explain the present by the past, or it means nothing.

A Retrospect. Let us, then, go back to the earlier stages of the developed body or mechanical laboratory. We find that the body of any living individual began as a *single* cell. One typical single nucleus, like the nucleus of any cell in our bodies, and containing the same number of chromosomes as each of them, was, in fact, the earliest stage of each of us. From it all of the countless millions of cells, of almost countless kinds, have actually proceeded. It *is*, indeed, "the organism that divides itself into cells;" and when the psychologist and the philosopher assert that the idea of personality is really valid, anatomy and physiology and their demonstrations notwithstanding, and that we are right when we feel that we are individuals, unities, personalities, embryology verifies this belief by pointing to the undisputed fact that each of us was once a single cell.

Curiously enough, Professor Bergson does not avail himself of the cogent and strictly evolutionary argument which is thus furnished for the view which he has largely helped to establish in contemporary biology, that it is the organism, a single individual being, which dissociates itself into the millions of cells which make its mature body, and the multiplicity of which seems to give the lie to our belief in ourselves as individuals at all. The single living cell which was the earliest stage of the myriad-celled body of each of us was the outward and visible symbol of the unity of the inward and invisible *psyche* or soul which informs the body, made it, and moves it.

Professor Driesch's Experiments. Bergson, like his predecessor and spiritual parent, Spencer, is a philosopher, not an experimental scientist. But in Heidelberg there works the greatest of German biologists today, Professor Hans Driesch, famous everywhere as a master of experimental science. Driesch in Germany, with his experiments, is complementary to Bergson in France with his philosophy. And, as we have just seen how important are the facts of embryology, of the development and evolutionary history of the living organism, for the understanding of the problems which its mature state presents to us, the reader will not be surprised to learn that it is the experiments and observations of Driesch upon embryological processes that have made such a profound impression upon biology during this century.

In 1907, the year which also saw the publication of Bergson's "Creative Evolution," Prof. Driesch delivered his Gifford Lectures before the University of Aberdeen. These are now published, under the title "The Science and Philosophy of the Organism," in two volumes, which are among the master-works of contemporary science. Here our duty is simply to note the general result of his experiments, and its bearing upon the problem before us. Driesch has experimented upon various forms of primitive and minute organisms, in their earliest stages, and notably upon a convenient animal for the purpose—the sea-urchin. He, and now many other workers, have subjected these living organisms to a large variety of *unusual conditions*, and of interference with normal development, as when a "fertilised ovum," or "segmentation nucleus," having already divided into four cells, is so shaken that the four fall apart, and their subsequent proceedings can be watched. Numerous other experiments, upon minute developing forms of life, have involved the production of certain injuries, with the object of seeing whether and how any attempt was made to repair the damage and to compensate for it. The simplest as well as the most complicated plants lend themselves to such observation as well as animal forms of life.

Vitalism—the Autonomy of Life. The truth which these experiments demonstrate can readily be described. It is that, when living beings in their stages of development, of body, tissue, and organ formation, are thus critically watched under various experimentally arranged conditions, what happens cannot be reduced to any laws of chemistry or physics, but can only be described as *behaviour*, with a purposeful and internal factor in it, which is definitely *not mechanical*. In Driesch's own words, the fact of living things which we call morphogenesis, or the genesis of their forms, the making of their bodies, "is not a specialised arrangement of inorganic events. Biology, therefore, is not applied physics and chemistry: life is something apart, and biology is an independent science." He thus clearly concludes: "We shall not hesitate to call by its proper name what we believe we have proved about morphogenetic phenomena. What we have proved to be true has always been called *vitalism*, and so it may be called in our days again. But if you think a new and less ambitious term to be better for it, let us style it the doctrine of the *autonomy of life*."

Driesch has reintroduced into modern biology an ancient term which is now again so celebrated, and so generally associated with his name, that we must learn it. Here are his own words:

"The great father of systematic philosophy, Aristotle, is also to be regarded as the founder of theoretical biology. Moreover, he is the first vitalist in history, for his theoretical biology is throughout vitalism; and a very conscious vitalism indeed, for it grew up in permanent opposition to the dogmatic mechanism maintained by the school of Democritus. Let us, then, borrow our terminology from Aristotle, and let that factor in life-phenomena which we have shown to be a factor of true autonomy be called *Entelechy*." This famous old word of Aristotle's means "something which bears the end in itself;" in other words, something which is not mechanical, but has within itself an aim, an idea, a purpose, perhaps, of some "far-off Divine event, to which the whole Creation moves."

The Question Answered. On various grounds, and in various ways, therefore, our question has been answered. The body does not make the soul; the brain is not the author but the organ of the mind; structure does not create life and its functions, but life is first, and one of its functions is the formation of structure, of the organism, or assemblage of organs, which will serve its purpose. The living being is thus a unity, notwithstanding the astonishing multiplicity of the body or organism which it evolves or creates for itself. It takes a soul to make as well as to move a body.

Evolution teaches us to look to the history of life for the explanation of its present, and thus, for instance, to find an origin for man in some monkey-like being, because monkey-like forms are assumed in the course of the development of any human body. When we continue with those embryological researches we find that the manner in which living bodies are made from the single cell, which is the beginning of all living individuals but the lowest, is definitely other than mechanical. It is original, creative, and "has its end (or goal) in itself."

In other words, Life is Mind, and its material products can only be compared to the products of that very mind as it shows itself in man. We may say, indeed, that, for instance, life made the eye as man made the microscope. We have already learnt that, along two utterly different lines of animal evolution, eyes of substantially identical type have been evolved, just as different men, in different ages and places and civilisations, have evolved, or created, similar contrivances, inventions, customs, arts, ideas. All alike, scallops and men, their eyes and microscopes, are products of "creative evolution," material expressions of the immaterial Being that rolls through all things.

C. W. SALEEBY

The Ideals of Good Buying. Necessity for Clearness in Drawing Contracts. Importance of a Cost Department. Some Difficulties and Problems.

BUYING AND COSTING

There is certainly no department of a great business where experience counts for more than in the buying department. No man can possibly be a good buyer who does not know the details of his business thoroughly, and who has not had a pretty wide experience of its various branches. He must also be keen and intelligent in watching the rise and fall of the markets, and must be capable of striking a bargain with men as keen and as well posted as himself. How essential all this is will be appreciated when it is realised that in these days of close competition and big turnovers with moderate profits the whole difference between gain and loss depends very often upon the successful buying of raw materials.

Importance of Watching the Markets. By just missing the turn of the market and buying a little too late, all the profit that was to be obtained from a certain line of goods, when manufactured, may be swallowed up. The buyer of a large manufacturing firm has no time for long consideration; the grass must not grow under his feet, or he will be in the position of the unfortunate man at the pool of Bethesda—while he is coming another will step down before him and secure all the advantage that is to be obtained. This applies equally to the buyer for a smaller firm. In fact, a small firm offers just the same opportunities as a large one for skill and enterprise on the part of the buyer. While in a large firm the huge quantities of material required give exceptional opportunities for close deals, the results of really good buying are even more rapidly felt in the small business, where the money saved by bargains in purchasing bears a higher ratio to the gross turnover.

Ideals of Good Buying. The ideals to be aimed at in a buying department are threefold. First of all, the best materials for the purpose required must be secured; secondly, they must be obtained at the lowest price and on the most advantageous terms possible; and thirdly, the delivery by the dates required and specified must be guaranteed. When these ideals are attained, the buying department is exactly what it should be, and the firm of which it is a part is to be congratulated. Obviously, to achieve such results the head of the department must be a man of wide experience and keen business perception, and he must possess a rare faculty for dealing with men and making a good bargain.

Filing Price Lists and Catalogues. The successful buyer must have an exhaustive knowledge of the markets open to him, and he will take care that in his department price lists and catalogues are carefully filed, so as to be available at a moment's notice. The best system here, as in the correspondence department, is the vertical system, although the varying sizes and styles in which price lists are prepared render filing rather less simple than in the case of correspondence. However, if there is any difficulty of this kind, it is easily overcome by arranging the catalogues in one or two classes, according to size, and filing them in drawers of different depths, and indexing them as 1*a*, 2*a*, etc., or 1*b*, 2*b*., etc.

It is important that the price lists, or catalogues, should be kept up to date, and, where they do not come in automatically, steps should be taken to get them by writing to the various selling firms. With a complete library of catalogues, the buyer has ready at hand exceedingly useful particulars of the sources of supply, and he can soon determine which firms he will call upon to tender for an order. It is always wise from time to time to get competitive prices, no matter how well the buyer has been served by any particular firm in the past.

Then there should be in the buying department of any firm purchasing on a large scale a card index, where various necessary particulars can be turned up at a moment's notice. Different cards will be devoted to records of the various materials purchased, and on each will be full details of past transactions—the names of the firms bought from, the quantities purchased, and the prices paid, with terms of settlement and delivery. It is very convenient to be able to turn up this kind of information easily and without delay. The details and method of keeping the record on the cards will vary according to the character of the business, but no large firm can afford to do without a card index system in its buying department.

Three Methods of Buying. There are, of course, various ways in which goods may be bought, and the principal methods may be described as direct buying, buying on commission, and buying by auction. In the first case the purchase is a direct transaction between the buyer and the owner of the goods. Materials are said to be bought on commission when they are purchased, not directly from the owners, but through the intervention of a third party, as a broker or agent, who receives a commission from the seller for his part in the transaction. Goods are bought by auction when they are put up at a sale and knocked down to the highest bidder. Different systems are followed in different businesses and in different markets, and each system has both advantages and disadvantages for the buyer. The methods that obtain in connection with the materials used in any particular business

can, of course, be learnt only by long-standing practical experience in that business.

General Principles of Good Buying. The general principles underlying good buying are that materials shall be purchased at the lowest possible cost consistent with good quality, and that they shall always be available when the manufacturing departments require them. This means, of course, that a buyer has got to be a far-seeing man. Anybody can go and buy a hundred tons of rubber, for instance, when it is wanted, at whatever price it is fetching in the market at the time, and then when some more is wanted, in, say, six months' time, it is a very simple operation to go into the market and purchase a second hundred tons at its then price. This, however, is not buying in the scientific sense of the term. The buyer must look ahead, and, in consultation with other heads of departments, estimate the forthcoming needs of the different manufacturing departments of his firm.

No matter what the material or materials he is buying, he will make himself familiar with the condition of the market, understand the best time of the year to buy, and study the rise and fall of prices. In connection with some materials it will be necessary to make contracts for forward delivery; that is, six months' or a year's supplies are bought on a contract which specifies that they shall be delivered in instalments at stated intervals, and paid for also at specified times. It should be mentioned that in these days of labour unrest the buyer must always be prepared for possible strikes and lock-outs, and also for delays caused by wars in those countries from which his staple materials are principally drawn.

Conditions of Purchase to be Made Clear. Every condition of a purchase and its payment should be clearly set forth in the agreement or contract or order form, to prevent any dispute arising in the future. It goes without saying, therefore, that the buyer must be thoroughly familiar with all the terms that are used to describe different conditions of payment—Cash on Delivery, which means payment when the goods are handed over to the purchaser; Net Cash, which means payment within a week or ten days without any discount; Cash against Documents, which means that the amount of the invoice is to be paid on presentation of the bills of lading, or other documents that prove shipment; and so on. In big manufacturing businesses such a huge amount is spent in buying raw materials that it is essential the conditions of payment should be very carefully considered, and the dates on which the amounts fall due spread more or less evenly over given periods, in order that it may always be convenient to meet the charges. It would be an unfortunate situation for a business purchasing hundreds of thousands of pounds' worth of materials if a large proportion of the payments fell due about the same time in the year. Matters of this kind are, of course, arranged by the buying department in consultation with the managing director and secretary or head cashier of the establishment.

Law of Contracts. It is absolutely essential that the head of a buying department should have a good knowledge of the law of contracts. He must make himself thoroughly familiar with the Sale of Goods Act, which contains most of the law relating to the sale and purchase of goods in the United Kingdom. The Act is in remarkably clear language for an Act of Parliament, and its provisions can be easily followed and understood. The buyer who has not got it at his fingers' ends will find himself hopelessly at sea, and may involve his firm in difficulties.

Goods, for instance, may be bought by sample or pattern, or by description. In the former case it is, of course, understood that the goods must be equal to the sample or pattern that has been approved by the purchaser, and where there has been a sale by description the goods as delivered must correspond with the description. Sometimes, however, the sale is by sample *and* description, in which case the goods must correspond with the description as well as with the sample. It is not sufficient that they be up to the sample if they are not also equal to the description that has been given.

The Right of Rejecting Goods. The buyer who has not previously examined the goods he is purchasing can claim by right a reasonable opportunity of examining them, to see if they are in correspondence with the terms of his contract, and he is not deemed to have accepted them until he has had such an opportunity. If, however, he writes to the seller saying that he accepts them, or if he does anything that is inconsistent with the seller's ownership, then he is considered to have accepted the goods, and is liable for payment according to the terms of his contract. Such questions as to whether it is the duty of the buyer to take possession of the goods, or for the seller to forward them to him, should be clearly specified in the contract, to avoid all possibility of dispute on either side. When goods are not up to sample or description, or when the quantity delivered is less than that contracted for, the buyer is at liberty to reject them. If, however, the buyer accepts the smaller quantity of goods delivered to him, then he must pay for them at the rate specified in the contract. If, on the other hand, the quantity is right, but the goods are mixed, some being in accordance with the description or sample and others inferior, then the buyer has the option of rejecting the whole or of accepting just that proportion that is in accordance with the description or sample. The provisions relating to shortage of delivery, however, it must be explained, are subject to any peculiar trade usage, special agreement, or regular course of dealing between the parties. In any case of rightful rejection the purchaser is not obliged to return the goods; he merely has to give notice of rejection to the seller, who must send and fetch them.

It is, of course, a very general thing for a buyer, when purchasing materials, to arrange a contract for delivery in instalments, these to be paid for separately. If the seller does not keep to his part of the obligation, the buyer's remedy

depends upon the terms of his contract, and this makes it important that in this matter the terms should be very clearly stated. It should be distinctly set forth whether, in the case of failure of the character described, the whole contract is to be repudiated or a claim for damages is to lie. The seller has equal rights if the purchaser declines to take delivery of the instalments, or fails to pay for them at the times specified. If the arrangement is not stated in the contract, the buyer is not obliged to accept delivery in instalments, and this only emphasises what has already been said—that the terms of all contracts of purchase should be clear and distinct. If goods are bought on approval, the purchaser has the right to accept or reject them as he likes.

Sometimes the buyer may explain in writing the particular purpose for which he wants the goods he is buying, and may imply, even if he does not actually say, that he relies upon the seller's skill rather than his own. In such a case the law considers that the seller has undertaken that the goods shall be reasonably fit for the purpose explained by the buyer.

Insuring Delivery as Required. It will be seen from all this that the principles and laws of buying are based on common sense, but it is important that the buyer should bear in mind all the facts that have been mentioned. Seeing how essential it is that the manufacturer should be able always to have the necessary supplies of raw materials, so that the work of the factory may not be brought to a standstill, it is important for the buyer to see not only that his contract is clear and specific as to dates of delivery, but that the firm from whom he buys is of such standing that it will be able to carry out its part of the bargain. This question of stability is a very important one, and comes up in connection with the comparison of estimates. So that they may secure an order, some firms will quote a price which is less than should be quoted, and which leaves no margin of profit for themselves. This is really gambling, and, unless the firm is a very large one and of great strength financially, it is for the buyer to ask himself whether the firm will be able to fulfil its obligations if it gets the contract.

Terms used in Buying. The buyer must always know what the price quoted includes. The goods may be quoted f.o.b. (free on board), which means that the price includes packing, railway, dock, lighterage, and all other charges up to and including the placing of the goods on board ship; f.a.s. (free alongside), which includes the charges involved in placing the goods in lighters or barges alongside the vessel ready to be taken on board; c. and f (cost and freight), which includes all charges, with the cost of bills of lading and freight, to the port of destination; c.i.f. (cost, insurance, and freight), which includes all the c. and f. charges, together with marine insurances; or franco, which means "free," and usually includes all charges up to the time the goods are deposited on the premises of the purchaser. There is, however, a good deal of latitude about the expression "franco," and a buyer must be careful to ascertain exactly what the seller implies by it, as sometimes merely c.i.f. is intended. There are other terms and conditions, with all of which the buyer must be absolutely familiar, or he will find that when he has purchased goods at what he supposed was an inclusive cost, there are many other charges to go on.

Where goods arrive in a damaged condition, the question sometimes arises as to whether the damage was done during transit or was the result of carelessness or accident on the part of either buyer or seller. It is well, therefore, for the buyer to know that legally goods are said to be in course of transit from the time when they have been delivered to the carrier until the time that the buyer or his agent actually takes delivery.

Of course, there will be a regular routine of ordering. As already indicated under the heading of FACTORY ORGANISATION, the storekeeper will requisition fresh supplies from the buying department. All orders should be made out on official forms, and a duplicate filed in the buying department for reference. There should be clearly printed on all orders sent out the fact that "no orders will be recognised that are not written upon the firm's official order forms."

Use of the Telephone in Buying. Formerly the buyer connected with a manufacturing firm situated in the country was at a great disadvantage. Either he had to be away from his firm's premises altogether, or, if he was there, then he had to rely upon an agent in London or other large centre. Now, however, with the telephone, no matter in what part of the country a firm's premises may be situated, the buyer can keep himself posted as to the condition of the market from hour to hour, and can buy by telephone, so that he is practically in the same advantageous position as the man who is actually on the spot.

Nothing has been said here about the necessity of a buyer knowing the metric system of weights and measures, and being familiar with Continental commercial customs, if the materials which he has to purchase must be bought on the Continent. The foreign exchanges, shipping details and documents, Customs formalities—these and other things will all have to be studied carefully, for it is the man with the greatest knowledge of such details, all other things being equal, who will prove the best buyer.

Importance of the Cost Department. To pass from the buying department to the costing may seem somewhat arbitrary, and there is, of course, no closer connection between them than between the costing and manufacturing departments. It is, however, with the results of the buying that the cost department has largely to concern itself. Material and labour are the principal items of cost, and the cost of materials depends largely, as will already have been seen, upon the skill of the buyer. Some method of arriving at costs has always been necessary, but it is really only in comparatively recent years that costing has been developed upon definite lines, and has become an exact science. In modern businesses the

cost department is one of the most important, and many of the big positions in such businesses are filled by men who received their training and experience in the cost department.

Absolute Accuracy Needed. A volume would be needed to describe in detail the various systems of costing that have been devised, and in this chapter all that can be done is to give a general idea of the principles involved. Like everything else in business, the details must be worked out, and any keen and intelligent man will be able to see how the principles described can be applied to any particular business or trade in which he may be interested. So much depends upon accurate costing that it is not surprising to learn that only really live and able men are likely to get on the staff of a costing department. Estimates for future work are based upon the costs of past production; and as the selling price of an article is also based upon the cost, as worked out in the cost department, it is clear that any mistakes or miscalculations in arriving at the figures are likely to have very serious effects upon the future of the business. If on the one hand the cost of an article is reckoned at less than it really is, a loss or at any rate a very inadequate profit is going to be made, while on the other hand, if the cost is reckoned as more than it really is, the firm is going to be absolutely out of it when quoting for contracts in competition with other firms; their price will be so much higher than those of the other manufacturers.

The Use of Detailed Cost Accounts. This, however, is not the only purpose of having detailed cost accounts. They are extensively used in eliminating waste and bringing down the cost of production, because by filing all records on the card index system a firm is able to compare the present cost of production of a certain article or line of goods with similar work done six or twelve months ago, and if the present cost is higher to follow the manufacture through step by step and see where the extra expense has been involved. Perhaps it is found that the operation of putting the article through a certain machine has been longer than in the former case, or perhaps a certain workman spent half as long again upon a certain operation as he did the previous time. In such a case steps can be taken to see that these particular stages of the process of manufacture shall be speeded up so as to equal or beat the earlier record. Thus wastage along any particular line can be detected and eliminated.

Only a man who has an inside knowledge of a trade can possibly organise and control a cost department. To initiate and conduct such a department involves the expenditure of money, but such expenditure is the best economy, and all large manufacturers have found it so.

The items of cost in manufacture with which the cost department has to concern itself are threefold; first of all, the materials used; secondly, the labour utilised in turning this into the finished product, and thirdly the indirect charges, which may themselves be divided into two classes—(*a*) expenses of production other than direct labour, such expenses as, for instance, wages of factory management, overseers, foremen, etc., motive power, rent, rates and taxes, lighting and heating, water, repairs of factory buildings, and so on; and (*b*) other indirect expenses such as administration, including salaries of directors and managers, upkeep of offices, expenses of selling, including salaries and commissions of travellers, advertising, distribution, and so on, bank charges, interest on mortgages, bad debts, etc.

The Cost of Materials. First of all, then, with regard to materials. As already explained, the manufacturing department requisitions from the stores a certain quantity of material for a certain job, and the requisition card with full details of these materials is sent to the cost department. Should there be any surplus of material when the job is finished, it is returned to the stores and a credit note given, which is also sent to the cost department. This department works out the total net cost of the material thus used on the job, writes it on the card, which is duly filed under the name or number of the job. In due course there will be placed with it cards setting forth the other items—labour, indirect expenses of production and administration, etc. So that the cost of the materials used in a certain job shall be accurately specified, it is absolutely essential that any surplus shall be sent back *at once* to the stores and credited. If the bad practice, which still obtains in some factories, of taking some of this surplus material to use in another job without first returning to the stores is allowed, it is obviously quite impossible to work out the accurate cost of any article.

No materials must be given out from the stores without the details and the name of the job for which they are wanted being sent to the cost department. The books of the accountants can be kept right from these records. If, for instance, when fresh stores are bought and paid for, it is the custom to charge up the invoice against a certain department, any of those stores not used by that department can be credited to it, on an intimation from the cost department. Thus, locks may be bought in large quantities by a desk manufacturer for placing upon the school desks which he makes for sale, but a number of the locks may be used for repairing cupboards in the office and factory. The cost department on getting the requisition would see that the accountants credited the manufacturing department with the right proportion used in the office, and debited the repairs department with them.

Controlling Waste. The simplest part of the costing of a job is dealing with the materials. To arrive at the right figure it is only necessary to assemble the requisition cards for the various store materials used, to work out the costs of these materials, and to add the sums together. It is by filing such records and comparing them from time to time as similar jobs are done that waste is controlled. For instance, the proportion of spoilt material can be watched, and if it tends to increase for similar work the

matter is detected at once and can be looked into. Not only can materials be checked in this way, but tools also. If, for instance, a larger number of saws or files are requisitioned over a given period as compared with a corresponding period at an earlier date, then the excess is noted at once and the reason for it can be investigated without delay. In reckoning the cost of materials, every outlay must, of course, be taken into consideration—that is, not only the charge on the invoice of the sellers but freight, unloading charges, etc.

The Cost of Labour. The next item with which the cost department concerns itself is wages, the wages of the men actually engaged in the manufacture of the article, and not including the overseers, foremen, etc., whose labour is only indirectly concerned in the process. This is, of course, a more complicated business than arriving at the cost of materials. There may be many processes, and sub-departments, and men involved in the manufacture of one article, and there may be different ways of paying different men. In order to arrive at the cost of labour on any particular job it is necessary that there should be some accurate record of the amount of time spent on the job by each man, if payment is by time, or the exact amount for the job if payment is by piecework.

Various methods of recording the time spent by each man on each job are in vogue, and, of course, the method followed by any particular firm must depend upon a variety of things, such as the situation and area of the workshops, the character of the business carried on, and the size of the firm. In some factories each man has a card, and when he is put on to a job the name of that job is written on the card, together with the time at which he started upon it, space being provided for such entries. Then, when he has finished that job, he takes his card to the foreman who enters up the time at which he finished. In this way, when the cards at the close of day are taken to the cost department, that department can not only total up the time worked throughout the day for the purpose of arriving at the wages due, but can also allot the proportion of these wages that is to go against each particular job.

Time Sheets. This method, however, where a large number of men are employed, wastes far too much of the time of the foreman, who ceases to be a foreman and becomes a clerk. It is the practice, therefore, in many large factories, for a special clerk to be employed in each department entering up the times on the men's cards or sheets. This method, and also that of having mechanical time registers in the workshops, by means of which the men themselves register the times at which they begin and finish their different jobs, are very good for compact workshops, but for large and scattered departments the time wasted by the workmen in going to and fro to the clerk or recorder between the jobs is far too great to make the system economical.

A better system is to provide each workman with a pad or book of time slips, on each of which spaces are provided for recording the name of a job, the time at which it was begun and the time at which it ended; also the date and the workman's name and number. The man enters up the time when he is given a job, and this is initialled by the foreman, and also the time when the job is completed. If the foreman is a keen man worthy of his position, the risk of the workman cooking the figures—putting down wrong times so as to make the total time worked appear greater than it really is—is small. The importance of having the right date on each slip must be emphasised, and, in order to help the men, bold tear-off calendars should be hung in conspicuous positions in the workshops.

These time slips will be useful for comparison with the time sheets from the mechanical recorders where the men punch on as they come to and go from the factory morning and afternoon. It will be seen at once whether there is any undue delay in getting the men to work. If, for instance, a man punches on at eight o'clock and the time at which he began his first job, as recorded on his time slip, is 8.20, it will be obvious that there has been a loss of twenty minutes. The matter can be looked into and some remedy for expediting matters first thing in the morning devised.

Indirect Labour Charges. The next matter for the cost department is to allocate a proportion of the indirect charges to each job, and this is a more complicated business than either of the items already dealt with. In addition to the work of overseeing and the cost of machinery, lighting, and heating, etc., there are many operations which have to be carried out regularly in the factory, and which, though they cannot be reckoned against any particular job, must have a proportion charged up against the cost of everything done. These operations include such things as sweeping and scrubbing the floors, cleaning the windows, painting and whitewashing the workshops, repairing the machinery, and the work of the night watchman.

The cost of materials and direct labour can be arrived at with scientific accuracy, but this cannot be done in the case of the indirect expenses that have been enumerated. A close approximation must, however, be aimed at, and the general method of apportioning the indirect labour charges is to reckon these on a time basis. To make the matter clearer, if a certain job takes six hours and the factory week is one of 48 hours, then one-eighth of the wages paid to overseers and foremen engaged upon the job must be reckoned against it. Of the wages of cleaners, painters, etc., one-eighth of the proportion charged against the particular department concerned would be reckoned. This is the principle as set forth by the simple illustration given, but in many businesses, with a variety of departments and highly specialised labour, the work of allotting the indirect charges is very complicated indeed.

Similarly, the cost of machinery, lighting, heating, rent, rates, etc., is apportioned on a time basis. For instance, a certain machine costs

so much per week of forty-eight hours to run, and a certain electric light so much per hour for current, then from these is reckoned the proper cost of each item to be charged up against a job that took, say, eight hours to perform. Depreciation of plant must also be taken into account, and a proportion reckoned against each job done in the factory.

Administration Charges. The last class of items to be charged to cost are those of administration, including directors' and managers' salaries, upkeep of the office, interest on mortgages, etc., and the selling expenses, which include cost of travellers, advertising expenses, cost of distribution, and so on. These are still more difficult to allocate in a complicated business with many lines than the previous class of indirect charges, but they can be approximately arrived at in a similar way. All the indirect expenses are generally referred to under the heading of establishment charges.

Selling Price Based on Cost. Based on some such system as has been described, the actual cost of an article is arrived at, and then the management can decide what percentage must be added to give a selling price that yields an adequate profit. It is in fixing the selling price that the great advantage of knowing exactly what the cost of an article really is comes in. When all the expenses are taken into consideration, and establishment charges are included, it is known that any difference between the cost and the net price received for the article is an actual profit.

Difficulties of Costing. It might be thought that all the indirect charges could be lumped together and a single percentage of these charged up to each job, according to the time it occupied, but a little thought will show that no such simple way of solving this complicated problem will give any right idea of cost. For example, there may be a very expensive machine which is required only for a certain class of work; and if there is a general pooling of indirect charges, then a relatively smaller proportion of the cost of working this machine is set against those jobs for which it is used than should be, while simpler works for which the machine is not used at all have to bear their part in its expenses. It is to overcome this difficulty that what is known as a machine rate is introduced, the method already described of charging so much per hour for every machine or expensive tool used in making a certain class of goods.

All kinds of complicated questions arise in connection with the determination of establishment charges, and no universal method of settling these questions satisfactorily has been found. For example, the machine rate method is only thoroughly satisfactory when the machine in question is being worked full time during the factory week. If it stands idle a large proportion of the time, then the machine rate charged against each job is far higher than it should be. Then, again, a real difficulty in connection with costing is this. When the factory is working at full pressure the establishment charges are divided over so many jobs that the cost per job is low. This is at the time when there is plenty of work, and fresh orders are not badly wanted by the firm. But when work is slack and new orders are eagerly desired, the short time being worked raises the establishment charges on each particular job, and makes it more difficult to estimate for orders against prosperous competitors.

No Universal System of Costing. It is clear from what has been said that there is no universal system, and that no hard and fast line as to details can be laid down. Every business must work out that system which is best adapted to its needs, remembering always that the costing system is for the business, and not the business for the costing system. In some businesses, for instance, which are very highly departmentalised, the indirect charges will have to be still further divided up. It may be necessary to reckon separately the rent or building charges for each department in the one factory. This is arrived at by taking the total charges in this line and then dividing them up according to floor space, so as to have a charge of so much per square foot per hour.

The Value of a Proper Cost System. The great advantage of having a proper cost department is realised when we remember that without it a manufacturer cannot know which departments are paying and which are losing. His profits may grow from year to year, but this does not necessarily mean that all the lines he is turning out are profitable. Some departments may be so profitable as more than to make up for losses in other departments, and it may be a fact that it is well worth a manufacturer's while to close down certain departments. If they stop, his profits may be more, though his turnover be less. This kind of thing, important as it is, can only be found out when there is an efficient cost department installed in the business.

Of course it must not be supposed that the costing of any particular line of goods can be done once and for all. In these days of fluctuating prices, the cost of the raw materials used in manufacture varies so from year to year, and in some businesses from month to month, and the cost of labour also varies so much, that every separate output of the same line must be properly costed. For, as has already been explained, quite apart from cost in the narrow sense, the work and records of the costing department provide materials for checking the rate of output and waste, and on this side alone make for greater efficiency.

The Relation of Estimating to Costing. A word must be said in conclusion about the relation of estimating to the cost department. Estimating in the old-fashioned business was largely a matter of chance, but a reference to the records of the cost department places the preparing of estimates on a scientific basis, and does away almost entirely with those errors which have so often proved disastrous even to prosperous businesses — under-estimating, with the consequent loss of revenue and profits; and over-estimating, with the resultant loss of valuable orders.

CHARLES RAY

The Function and Structure of the Ears. How they Reconstruct Sound. Tyndall's Sound Flame. Analysis of Sound.

HOW WE HEAR

We may now turn to the consideration of the physical aspect of hearing, which is also dealt with in a later chapter in PHYSIOLOGY. And by way of an introduction to the subject we may begin with a simple and easily dismissed question: How are we able definitely to locate a source of sound?

The Direction of Sound. The use of the external ears in the lower animals is obvious to anyone who has observed them. It is evident that if these ears be inclined at different angles the animal will find a given sound louder when the ear is at one angle than when it is at another. He is thus immediately guided to the source of the sound. Most people have completely lost the power of moving the ears at all, though some of them can move the ears in association with movements of the whole scalp, while a few retain the power in some smaller degree. But no one ever uses it for the purpose of estimating the direction of sound. In any case, the ear has so largely lost the shape which should make it valuable that the power would be of little value if we retained it. It has been shown that if the whole of the external ear be filled up with wax, leaving just a small hole corresponding in width to the canal that leads inward to the middle ear, the acuteness of hearing is very slightly diminished—that is all.

Do our Ears Deceive us? Now, it may be argued that, in reality, we cannot judge the direction of sound, but are constantly deceived. The deception, however, is more apparent than real. We are deceived merely because the sound is reflected from some surface, and we locate the source of the sound in the direction of that surface. Nevertheless, our ears have served us quite faithfully in indicating the direction from which the sound immediately reached them.

The most careful experiments have been made in order to discover whether there is any factor whatever that determines our appreciation of the direction of sound except the one factor which we are about to discuss. It is found that no other explanations of this power can be afforded.

Our appreciation of the direction of sound entirely depends, then, on the fact that we have two ears. We hear a noise, and immediately turn to the left; the simple reason is that the sound is more loudly heard by the left ear—that is to say, by the right side of the brain—than by the right ear—that is, by the left side of the brain.

How Sound Comes to the Brain. Observe the curious fact that the hearing is really done most effectively not in the part of the brain which is nearest the sound, but in the part which is farthest from it. The explanation obviously is that the brain appreciates not directly from the external world, but through the mediation of the organs of sense, and in the case we are considering it is the left ear that is most markedly stimulated. Various experiments—both those made for the purpose and the experiments of disease—go to prove that our internal comparison of the relative measure of stimulus received by the two ears is our means of determination.

The case is parallel to that of the eyes. In each instance the development of pairs of organs would appear to have been originally due to the same causes as have produced the double symmetrical arrangement elsewhere in the body. But whereas no extra value of any special kind is due to the fact that we have, for instance, one lung on each side of the body, the similar possession of two eyes means not merely that we are able to see things more intensely, but also that we are able to perceive their form in perspective by an unconscious comparison of the slightly differing images which the two eyes perceive; and, similarly, the possession of two ears enables us not merely to perceive sound more acutely, but also to perceive its direction.

A Puzzle in Sound. It is an obvious consequence that, if we produce sound in such a fashion that it is absolutely equidistant from the two ears, we shall be able to defeat any possibility of locating it, except in so far as the subject of the experiment is able to say that the sound *is* somewhere equidistant from the two ears. In order to obtain success with the following experiment, it is necessary that the acuteness of hearing in the two ears be equal. The subject is blindfolded, and a noise is made by the finger and thumb, or any other means, just in front of his nose, under his chin, or at the back of his neck. From the fact that the sound is heard equally in the two ears, the subject will rightly confine his guesses to the plane in which these places lie, but as to the exact part of the plane from which the sound proceeds he will be completely nonplussed. A sound produced under his chin is as likely to be referred to the top of his head or to the back of his neck as to its actual source. This experiment affords a very conclusive proof of the accepted theory. The actual mechanism by which we appreciate sound is dealt with in PHYSIOLOGY.

The Structure of the Ear. The sound-wave which has been more or less collected by reflection in the external ear passes through a short canal, at the bottom of which is found the *tympanum*, or *drum* of the ear, which is thrown into vibration synchronous with—that is to say,

at the same rate as—the alternation of compressions and rarefactions that constitute the sound-wave. To the inner side of the drum is attached a small bone, which is joined to another and it to a third. These three *auditory ossicles* (ossicle meaning a small bone) form a very oblique bridge across a narrow, air-filled cavity which, though really little more than a slit, is known as the middle ear. The air which it contains is supplied from the throat by means of a special channel which is known as the Eustachian tube. This permits the air to pass in or out, so that its pressure may always be the same as that of the air on the outer side of the drum—that is to say, that its pressure may be the same as whatever happens to be the atmospheric pressure at any given moment. The persistence of this equality of pressure is necessary for comfort and also for hearing successfully. [See PHYSIOLOGY.]

The Middle Ear. The business of the three bones is to transmit the to-and-fro vibrations into which the first is thrown in virtue of its contact with the tympanum. Two minute muscles are attached to these bones, one of which, when it contracts, tends to tighten the drum of the ear so that it responds more readily to aerial vibrations of small amplitude. The hearing is thus made more acute, and we therefore employ this muscle when we strain to hear. When the second muscle contracts, it tends to lessen the rigidity of this threefold conducting apparatus. It is therefore of value when we try to reduce the intensity of loud sounds. Sometimes it is paralysed, and then loud sounds are found to be very painful. This muscle is the nearest approach that we possess, as we have no ear-lids, to an apparatus for cutting off external vibrations—which our eyelids do so efficiently for the eyes.

The Inner Ear. The third and last of the three bones is fixed to another membrane, which is thrown into vibrations corresponding to the vibrations aroused in the tympanum, and which closes a remarkable canal fille dwith fluid, the said canal being part of the internal ear, the essential part of the organ of hearing. The sound vibration, more or less modified in amplitude, perhaps, by the action of one of the muscles we have named, is communicated to the fluid of this canal, which takes a spiral shape that has some resemblance to the shell of a snail, though it is very much smaller. This canal lies in the hardest bone in the body—the hardness and rigidity of which are of value, in that they do not tend to damp sound-vibrations which are appreciated within it. As the sound-wave travels along this spiral canal, it naturally affects an extraordinary structure which lies along the whole length of a continuous bridge or partition that divides the canal into two. This structure is known as the organ of Corti.

The Piano Theory of Helmholtz. As the canal steadily diminishes in width through its entire length, it follows that the fibres constituting the bridge become shorter and shorter. This fact aroused the careful attention of the illustrious German physicist Von Helmholtz, whose name will go down to all time as one of the founders of the doctrine of the conservation of energy. Helmholtz supposed that, as in the case of a piano, the shorter fibres of this bridge—those that lie nearer the apex of the spiral—correspond to musical notes of higher pitch, while the longer correspond to the low notes. This may be described as the theory of sympathetic vibration, or, more briefly, the resonance or piano theory of hearing. This theory has been widely held, but it is extremely difficult to perfect it in accordance with the facts. It is, however, most remarkable that there have been recorded numerous cases of partial deafness where the patient was able to hear every note on the piano, perhaps, except one, or a sequence of two or three. In such cases it has sometimes been found that there has been some destruction of the structure of the internal ear, more or less corresponding to what might have been expected on the assumption that the piano theory of Helmholtz is correct.

The Function of the Cells. At any rate, the fibres of this long bridge are covered by a company of tiny living cells, which are provided with minute, sensitive hairs. They must be regarded as the true auditory cells, corresponding to the distinctive visual cells of the retina of the eye, which are the immediate means of our appreciation of those ethereal vibrations we call *light*. The hairs of the auditory cells doubtless appreciate every motion or change of pressure which a sound-wave from outside may impart to the fluid in which they are bathed. The base of each of these innumerable cells—the actual number being about 15,000—is directly supplied by a tiny branch of the nerve of hearing. But when we come to the transformation of material vibrations into nerve energy, we have reached the limit of what is ordinarily regarded as physical inquiry. The entire length of the canal we have described is about one inch. As this is very much shorter than the shortest wave-lengths of any sound that we can appreciate, it follows that the whole internal ear must constitute one vibrating system, the whole of which at any one moment is in the same phase. The structure is infinitely more complicated than we have described, and may be studied in more detail in PHYSIOLOGY.

How we Recognise Sounds. The question of the recognition of the pitch of a simple tone is difficult enough, but it is as nothing compared with the difficulties of understanding the means by which we recognise and appreciate compound tones. Perhaps the best fashion of understanding the extraordinary difficulty of such a feat is to use the following analogy, which the present writer suggested some years ago:

Let us take the case of the movements of an electron constituting part of an atom of matter upon the surface of the moon. This electron is partaking of a very large number of motions—even begging the hitherto unanswered question whether it is in rotation on its own axis. We are sure, at any rate, that

it is moving within the atom—probably revolving around the atomic centre. It also partakes in that movement of the atom as a whole which constitutes what we call heat. Together with the atom which it helps to compose, it must also be supposed to be drawn gradually toward the centre of the moon as she cools. It is also moving as the moon rotates upon her own axis, and as she revolves around the earth, and as the moon and the earth revolve around the sun. But astronomers tell us of the proper motion of the sun, and declare that the solar system as a whole is journeying at the rate of some eleven or twelve miles a second toward the bright star Vega in the constellation Lyra. Thus, there are seven or eight motions, and we know not how many more, which the electron is simultaneously performing. Upon these we may all be agreed, but at the same time we are also agreed that at any given moment the electron is moving in only one direction and at one speed, Its absolute motion is the consequence of the composition of all these relative motions.

"Hearing by Imagination." The case of the electron is extraordinarily similar to that of the particles of air in a complex sound-wave. The mind forbids us to conceive that any of the particles are moving in two directions at the same time. In order to do so we should have to think of them in two places at the same time. What, indeed, reaches the ear when we listen, for instance, to combined orchestra and soloists, is not the sound-wave corresponding to the voice of any of the singers, nor the sound-wave corresponding to any of the instruments. It is a wave of incredible complexity, the form of which is determined by all the sources of sound involved.

Each of these sources of sound can do no more than modify the form of the resultant wave in proportion to the form and amplitude of the wave which it would produce if, so to speak, it had the air to itself. In fact, then, when the ear of a musician distinctly hears the phrase which the violins are playing or the tenor is singing at any given moment, he hears what is not there. The wave-form corresponding to the violins or to the voice is represented merely by one phase of the complex movement which the aerial gases are performing. The ear is thus able to reconstruct, imaginatively, the rest of the wave from a mere fragment of it, and the listener thinks he hears the tenor's voice, whereas in reality he only hears a complex sound-wave, the form of which has been somewhat modified by the fact that the tenor has contributed his own tendency to it.

A Wonderful Power of Reconstruction. Similarly, in a clamour of voices, the result of which is one single wave-form, the ear is able, at choice, to listen to the whole as a clang or harmony, or to recognise from all these voices one that is familiar, or even to recognise in that familiar voice the particular relation of over-tones which may indicate any particular emotion, such as joy or fear. Yet, unless we are to accept the inconceivable proposition that the atoms of air can be in two places at once, we are compelled to recognise that the ear has reconstructed, from a mere indication, particular wave-forms which have no actual existence. This analytical or reconstructive power of the ear is the most remarkable of all our sensory powers, and is seen to be none the less so when one examines the complex wave-forms which the phonograph is able to record.

There is no analogy in the case of sight, which, indeed, is inferior to hearing in discrimination. Wherever we turn our eyes, any given portion of the retina, or perceiving curtain, at the back of the eye merely appreciates the particular ether waves that happen to fall upon it. Even if we fix attention on a particular part of the field of vision—a particular feature of the landscape or the freckle on the side of the nose of the person we are speaking to—there is no reconstructive or analytic power such as the ear possesses.

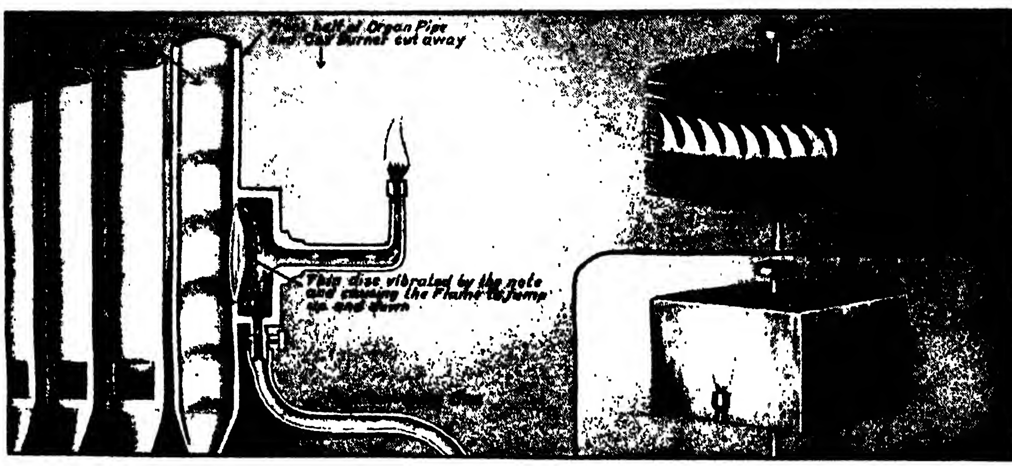
The Ear's Analysis of Wave Sounds. A complex wave-form consists of a number of ripples of varying size and shape, moulded upon bigger wavelets, which, in their turn, are moulded upon waves bigger still. Each of the little ripples simply indicates all that is left of the wave produced by—say, at a choral-orchestral concert—a given horn or violin or contralto when that wave has been merged in and blended with all the other waves that are coming from the stage. Yet from a mere hint, such as an amputated curve in the whole complex vibration, the hearing ear can reconstruct and imagine that it hears the voice of any of the soloists or the tone of any of the instruments in the orchestra. The case is even more remarkable, indeed, than, for instance, the reconstruction of an extinct animal by study of one of its bones; for in the case we are considering there is really left not even an amputated portion of the sound-wave belonging to any of the instruments or voices. It is impossible to point to any part of the wave-form and say: "The flute contributed that." If the diagram of the wave-form of the flute was superposed upon the diagram of the complex wave-form that is actually produced, there would be no coincidence between them at all. These considerations make this amazing power of the human ear more amazing still.

Sound can be felt. If we realise that sound has an objective basis consisting of material vibrations, it will be plain that, as we noted above, there are other means than the living ear by which sounds may be appreciated. They can, of course, be appreciated by the finger—that is to say, the finger can feel the vibrations of a vibrating object. There is a profound difference between the impression which such an object makes on the sense of touch and that which it makes on the sense of hearing. But the objective fact, whether we call it sound or whatever we please to call it, is one and the same.

The phonograph offers a simple illustration of the means by which sound vibrations may be felt, so to speak, and recorded.

Tyndall's Sound Flame. A number of experiments have been made with flames especially designed so as to be very sensitive to sound, the most celebrated of these being the so-called vowel-flame contrived by Professor Tyndall. This is about two feet high, and is extremely sensitive to all sorts of sounds and musical notes. It responds especially to tone of high pitch, and therefore to those particular vowels which contain the largest number of over-tones of high pitch. For instance, it is very much more markedly affected by the vowel *ee* than by the vowel *oo*. For we may here note that, as Helmholtz proved, the difference between the various vowel tones—every one of which may be sung on one and the same note—depends upon the variation in their over-tones. It appears that in the case of vowel production the over-tones are produced partly in the mouth itself. It would seem to be a conclusive proof of this fact that we are able to whisper the vowels. When a noise or musical note is made to which the flame responds, it will quiver in greater or less degree, or may actually be so much shortened as almost to disappear. The instant that the noise to which it objects ceases, it jumps up again.

Analysis of Vowel Sounds. The German physicist König has utilised these facts in order to make what he calls a *manometric flame*. If we take a series of Helmholtz's resonators and attach them to the manometric flame apparatus of König, it is quite easy to analyse any compound tone or clang [see illustration]. The diagram shows how the sound is made to throw a membrane into vibration on the far side of which the gas, as yet unlighted, is passing upward towards the flame. Now, in order to observe the movements of the flame, which are very rapid, it is necessary to look at its reflection in a rotating mirror. During silence this simply forms a long band of light, but it is broken up into various forms according to the sounds that are produced. These may be extremely complex in their shape in accordance with the complexity of wave-form of the sound that is being produced; and there is the coincidence that might be expected between the form which the altered flame takes in the mirror and the form of the marks produced by the needle of a phonograph under the influence of the same sound. It is especially by this admirable combination of the devices of Helmholtz and König that it is possible to analyse completely the nature of the various vowel tones. But even this method has been superseded, or, at any rate, supplemented, by the application of photography to the phonograph, and the subjection of the curves so obtained to mathematical analysis.



PICTORIAL DIAGRAM ILLUSTRATING KÖNIG'S MANOMETRIC FLAME APPARATUS

Harmony and Discord. Finally, we may note a few of the simpler facts of harmony and discord; and, in the first place, we must observe the peculiar phenomenon called *interference*, of which much more must be said when we come to consider waves of light. Interference is a phenomenon common to all forms of wave motion, and everyone has observed some consequence of it who has watched the rebounding of waves from a breakwater. Everyone knows how, when the two crests, the one of the advancing and the other of the rebounding wave, coincide, the water is very much raised. On the other hand, where crest and trough meet one another, they neutralise one another. This is why the phenomenon is called *interference*.

The musician knows interference because of his familiarity with what he calls beats. When two notes are sounded together, we get an unpleasant effect of sudden reinforcements of the sound called beats. In such cases we always find that the two notes are really very near one another—perhaps nearer one another than any two notes on an organ in tune can possibly be. These beats or throbs constitute the ultimate basis of discord. Now, discord is usually taken as synonymous with disagreeableness of sound, but the question of pleasantness or otherwise of sound is a matter of taste, and therefore not open to dispute. It all depends upon the number of beats which the individual ear can tolerate. Not only so, the occurrence of discords is of immeasurable musical value.

C. W. SALEEBY

Stagings for the Erection of Permanent Works. Methods of Union. Piling. Strutting. Bridge Erecting. Joints. Gantry Stagings. Derrick Stagings.

STAGINGS AND GANTRIES

Stagings and Gantries. The bricklayer's scaffolding made of poles and ledges, lashed together with ropes, and supporting putlogs and planks, has but a limited service in engineers' work, which is generally of so exacting and varied a character that something much more substantial is required. The stagings of the engineer are used for the erection of girder bridges, viaducts, steel roofs, piers, and allied work, taking the place of the centring of the bridges of stone and brickwork. The scaffolding of the engineer has to carry massive girders of steel, and often besides cranes and tackle for hoisting the same. These "temporary works," as they are called, are often constructed of steel, but with these we are not concerned. They are of rather a costly character, even though built of timber, because of the large quantity required and the labour engaged in their construction.

Little in the way of erection of permanent works can be accomplished unless provision is made beforehand for the support of the parts of a structure during the course of the erection. The centring for arches is a typical and familiar case. No matter how large the span of the arch is, the centring must be continuous to afford support to the masonry laid and built upon it until the structure is completed and the mortar has set. This is a case where the shape of the staging coincides exactly with that of the work built upon it.

The same principle is carried out in all cases where a horizontal plane staging is built to support during erection the floor of a girder bridge, the only method which was in use until about 1850. A firm base of this kind fulfils not only the function of support to the girders, but is also a safe platform on which men may move about, and where the tackle for hoisting and carrying can be sustained. Stagings of this kind are denoted by the term "false work," or "temporary work," to distinguish them from those which are real permanent structures.

In all contractors' estimates their cost has to be calculated as carefully as that of the actual structure, and added to it. Their construction may bear a large proportion to the total cost. In some cases they may equal or even exceed it. The quantity of materials required is large, and the plant and the labour costly.

Bridge-Building without Stagings. Because of this costliness, other ways of doing the work have been adopted when possible. The most important of these is the construction "on shore" of a span, or a portion of a span, which is then duly counterweighted, thrust out over a chasm or a stream. Allied to this is the method of floating out a structure on pontoons. These methods have come into use only with the practice of building with iron and steel, being obviously impossible with masonry. When stagings are erected in the course of navigable streams, the erection is complicated by the necessity of leaving a clear passage below. Then the cluster system is adopted. Groups of piles or standards are driven in near the piers only, and these are connected with horizontal members laid on them.

When navigation is not in question, or when stagings occupy a valley, the spacing may be equally distributed. Almost invariably stagings are constructed of timber. Sometimes a composite structure is adopted, iron ties and bracings being combined with timber piles and beams.

The strength of stagings has to be estimated by the same methods as those of the permanent structures. In wind-swept chasms and broad rivers, high factors of safety are necessary. In streams subject to severe floods, to floating ice, and in tidal estuaries, other risks arise, by the operation of which false works have not infrequently been involved in destruction.

An aspect to be born in mind in erecting false works is the diminution of the selling value of the materials after the completion of the contract. Therefore, as little necessary damage as possible is done to the materials used in the form of bolt-holes, tenons and mortices. As much length as possible is left uninjured in carrying out the necessary boring and cutting.

Gantries. There is also a type of staging better known under the term gantries, the functions of which may be identical with, or different from, the foregoing. Gantries are built for the erection of work simply, or they are structures for carrying travelling cranes, or erecting towers or skips, etc. The difference in the two is rather in function than in essential form or design. In the case of many architectural works of a large and substantial character, especially when masonry is much used, various forms of gantries, including derrick platforms, are very generally employed.

Trestles. Allied to these, again, are the trestles, or clusters of braced standards used for carrying horizontal staging, the timber staging for derrick cranes, the towers for aerial ropeways, all having in common the cross bracing of vertical members otherwise liable to bend only yield under loads.

Stagings, again, may be broadly divided in two groups—the fixed and the portable. The first is the more common, the second being used chiefly for the erection of bridges over deep streams into which piles cannot be driven. It is also employed in erecting gasholders.

Methods of Union. One feature which all these structures have in common is the method of union of the timbers. As these consist of

balks, mostly with some half timbers and plank decking, the fine work of the joiner is out of the question. The stub tenon and the joggle predominate, and the real agents of union are chiefly bolts, dogs, and spikes. The tenons and joggles prevent slipping of the timbers over one another, but their security depends on the bolts and other fastenings employed.

Bracing and Struts. Another essential characteristic is that bracings and struts enter largely into construction. The taller and longer the structures, the more importance do these assume. It is a familiar fact that one diagonal brace will prevent a rectangular frame from "going cross-cornered"—in other words, assuming the form of a rhombus. This fact illustrates one of the functions of bracings and struttings. But another of equal importance is that bracing puts the tall standards into the condition of short columns. This means that the tall sticks of timber, even though, say, 12 in. square, are very weak, and would bend and yield if unbraced; but when several of these are connected with diagonal bracings the strength becomes that of short columns of large area of base.

Fixed Stagings. Fixed stagings on land are built on squared timbers (balks) sunk into holes dug several feet deep in the ground, and loaded round with large stones. The ends are well tarred first. Similar stagings in streams or on dock sides, or on breakwater and pier work, are built on squared piles [**68** and **69**] shod with steel and driven into the soil. The real work lies here, since the difficulties are greater than with superstructural portions. Good piling is a firm foundation on which to build.

Piling. Piles are rendered capable of supporting a superincumbent load either by their reaching firm ground, or, when no such ground exists, by the friction of their sides against the soil. Much difference of opinion exists in regard to each of these, but when an ordinary monkey, let fall from its full height, fails to move a pile more than $\frac{1}{8}$ in. or $\frac{1}{4}$ in., it is considered that the pile has found a firm bottom.

The spacing of the piles is settled by the load upon them. About 1000 lb. per square inch of head is a safe load.

Stability is often studied by driving piles in diagonal directions instead of perpendicularly, imitating the batter of walls, and thus increasing the width of the base considerably. This can only be done in one direction as a rule, the exception being a structure with a base of square or oblong form.

It is not sufficient to drive piles firmly; they must be tied together in some way so as to enable them to withstand the rolling or rocking loads to which they will be subject. Piles are often tied together by straining chains with a tightening screw. The chains are attached to the piles which form the four corners of an enclosed rectangle, and are screwed up taut. Sometimes the fastening down of the cross timbers and decking is sufficient, but more often, especially in deep piling, the timbers have to be strutted [**69–73**] or connected with diagonal bolts crossing each other. It is not usual to place much reliance on bolt fastenings or on the end contact of timbers for stability, but to trust more to the judicious crossing and strutting, which prevent initial movements.

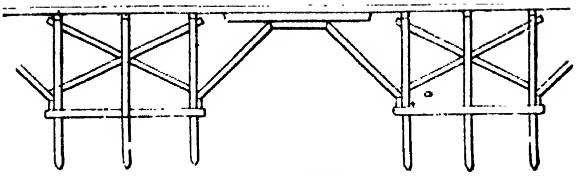
The uprights or standards of stagings erected on land [**73–75**] have the same functions as piles driven under water, and the remarks just made respecting tying them together and stiffening with struts or crossing bolts apply in every case whether the stagings are fixed or mounted on wheels.

Strutting. The strutting of main timbers when done properly renders movement in any direction in the plane of the struts impossible. The strutting is made double, equal, and in opposite directions for this purpose; the stress tending to move the structure as on a pivot to right hand or left is met by its strut or set of struts. The struts must, therefore, be provided with some suitable resistance. Here it should be obvious that no mere tenoned joint would hold the members firmly. Though stub tenons are sometimes used to prevent slipping sideways, they are never relied on alone, but straining pieces, joggles, or abutment pieces, as they are variously termed [**69**, **70**, **74**, and **75**], are employed. They may be long pieces bolted or spiked to the main timbers, or short chocks only, similarly fastened as shown in **74** and **75**.

These take the stresses on the struts, but the latter must be also bolted or dogged securely to the main timbers, the bolts passing through, and their heads and nuts resting on iron washers. The dogs are simply driven in just as the carpenter drives his little dogs or staples temporarily into timber. Too many bolts in timbers are objectionable, not only because they cost more to make and fit than dogs, but also because the bolt-holes lessen the value of the timber for sale. This, of course, only applies to temporary works.

Horizontals. The upper horizontal timbers must be adequately supported. If the piling or the standards are not very far apart, the horizontal timbers generally require no other support. Frequently, however, two sets of horizontals are used, laid one over the other, crossing at right angles. But, apart from this device, horizontals must be stiffened if they are supported only at long intervals. This is done either by strutting [**74**] or by trussing [**77** and **78**]. The first named is less costly than the second. But when timbers are very long, trussing is the only method practicable, and this may be single [**77**] or double [**78**]. In this the stresses tending to bend the timber downwards are transmitted to the truss or tie-rods, which are anchored at the timber ends, and in a strut of cast iron [**79**], or two such struts, fastened to, and projecting from, the bottom face of the beam. This device is not often adopted in temporary stagings, but it is usual in permanent gantries.

Tall Stagings. Tall stagings [**70**, **71**, and **72**] are essentially a multiplication of the single staging. They are necessary where the girders



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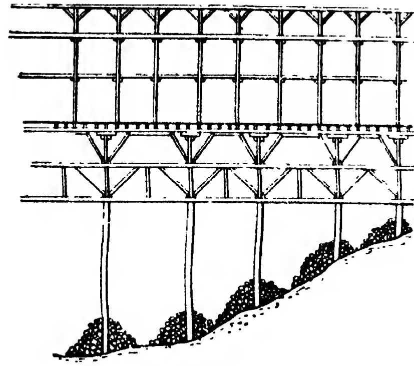

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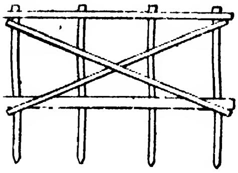

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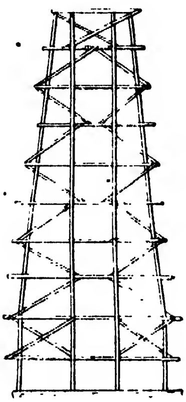

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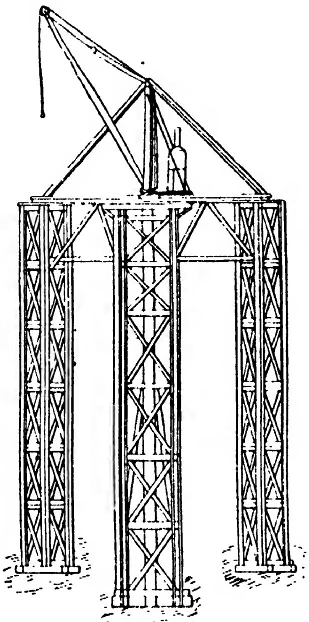

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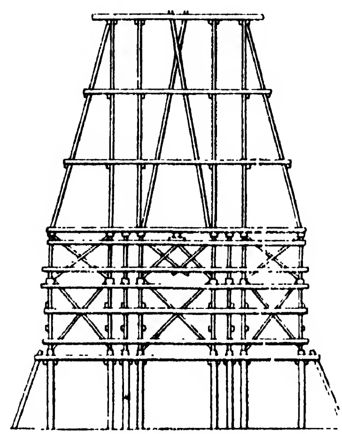

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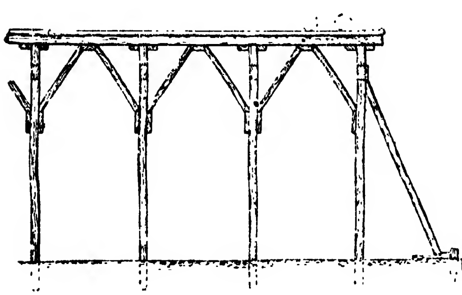

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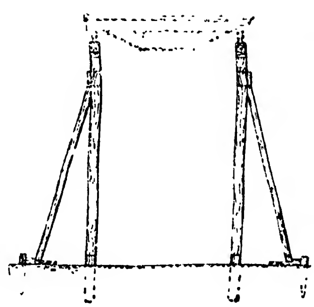

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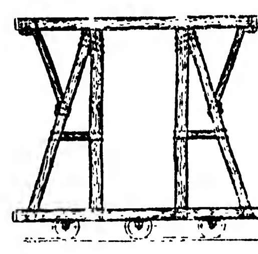

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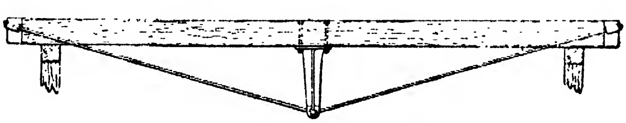

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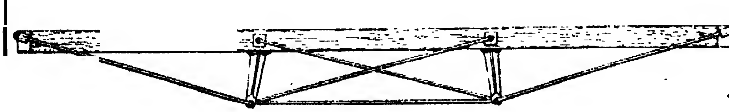

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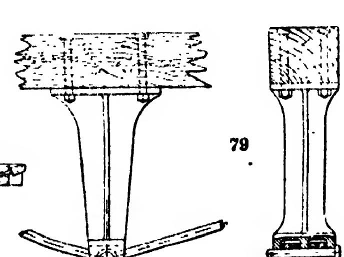

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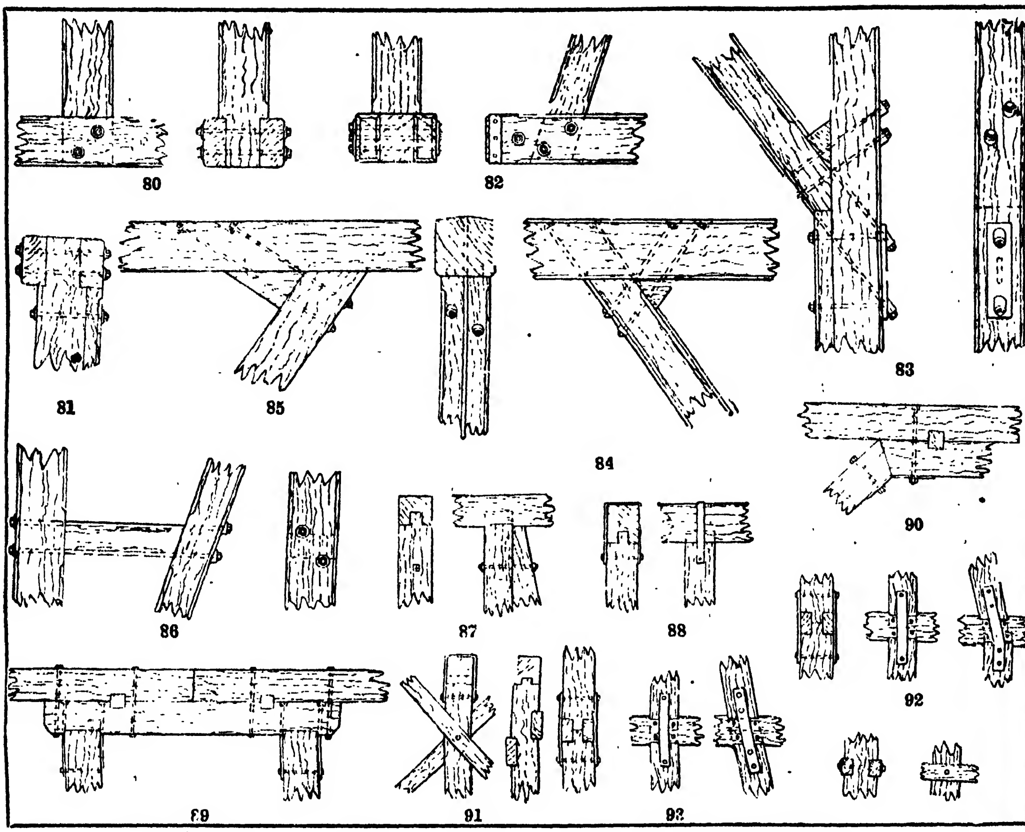
68–79. GENERAL FORMS OF STAGINGS AND PILES, WITH THEIR BRACES AND STRUTS



80–93. THE PRINCIPAL FORMS OF JOINTS FOR STAGING TIMBERS

for bridges and viaducts have to be carried across deep ravines. They are made broader at the base [71 and 72] than above, and the main members form several tiers, which are each strutted similarly to a single element. Around this general design engineers effect all kinds of modifications adapted to any particular piece of erection in hand.

Portable Stagings. Portable stagings embody the principles of construction of the foregoing in so far as the strutting and union of the members is concerned. The difference is that, instead of fixed piles or standards, the staging is mounted on flanged wheels [76], to run on rails, if on land, or is placed on a pontoon, or pontoons, if for bridge erection.

Bridge-erecting Stages. The stagings for the erection of bridges are of two kinds—those having the piles or standards spaced equally and those in which they are clustered. The difference between the two is as follows.

Equal Spacing. Here the bridge is erected on stagings which are placed at regular intervals [70], excepting near the centre of the waterway, where a space of double or treble that allowed elsewhere is given, in order to permit of navigation there. But at any other locality the stagings bar traffic. This method is only suitable where streams are not liable to flood or to drifting ice. It is a simpler construction than the cluster device, but in some cases uses a larger quantity of timber.

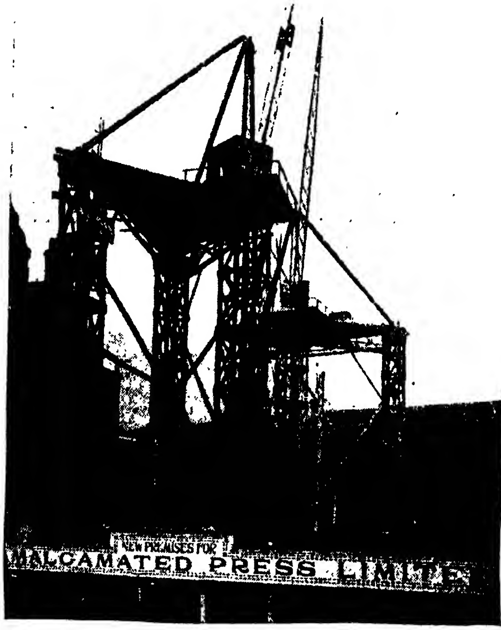
The Cluster System. In this [71 and 72] navigation is scarcely impeded, since the clustered standards are spaced widely apart. But this involves the connection of the tops of the standards by horizontal beams, so making a gantry. These beams of timber or steel are generally both trussed and strutted, to enable them to carry cranes and the bridge girders' loads.

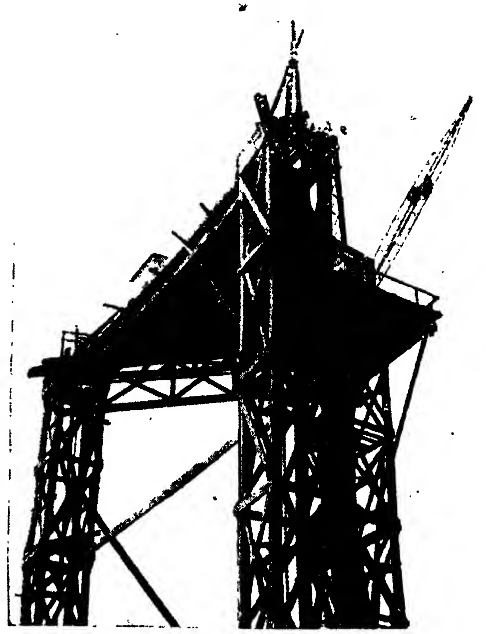
The standards for staging must consist of piles in swift streams, and in those like the rivers of Canada and North America, where floating ice comes down. It is also safer in slow-running navigable streams.

There are many cases in which it is not necessary to drive piles, but the standards are instead stood on the river bed and enclosed with a mass of rubble [70], to prevent them from shifting. Or the two methods are used in combination, some standards being driven, others not, and the bases loaded with rubble and the upper portions braced. On land, standards are sometimes carried on horizontal timbers [73], as, of course, they must be also when a travelling staging is mounted on wheels [76].

Choice of Methods. What particular method shall be adopted in any case is a question for settlement by the engineer, who has to take all the local circumstances into con-

TOWERING DERRICKS AND FIRM GANTRIES





GENERAL AND DETAILED VIEWS OF GANTRIES BEARING DERRICKS
In the right hand picture of the upper part of a gantry the method of framing should be noted, namely horizontal and diagonal bracing. The chain within is loaded as a counterpoise.

A TIMBER GANTRY CARRYING A TEMPORARY ROAD, SEEN FROM BELOW AND ABOVE
Features to be noticed in the left hand picture are the cross-bracing and side struts, also one skep discharging into a cart and another being filled below In the right hand picture we see a movable derrick discharging a skep direct into a cart, and the timbering with struts supporting them against the side of the excavation in the background.

sideration. The nature of the ground, the span, height, wind pressure, navigation, etc., all have to enter into the calculation, and a matter as important as any is that of cost.

Alternatives to Stagings. The staging method of erection of bridges is alternative to that of floating out bridge girders, or rolling them out from the shore, or building them out from their piers. It possesses the great advantage of giving the men a good platform to work upon, and under some conditions may thus prove less costly than other methods where no staging is used. The parts of the work that are being erected are not subjected to any strain, such as often occurs in the other methods, especially in the case of cantilever and girder bridges like that over the Forth, or the arched bridge built over the Zambesi. Every member is supported by the staging until the last rivet is closed, and each is then subjected only to the normal stress for which it has been proportioned.

Joints. The methods of jointing the heavy timbers for staging admit largely of repetition—that is, the forms used are not very numerous, but they occur again and again. Some of the principal are shown [**80-93**].

It may be laid down as an axiom that the less cutting done the better from the point of view both of economy and of strength; economy of time, and also in money, from the fact that the material is more saleable on the conclusion of a contract; strength, because deep cutting diminishes the strength of a section.

Still, as already remarked, it is seldom usual to trust to bolts alone for security, but joggling, even though shallow, is practised. Beams, stringers, transoms are notched or joggled, and struts are stub-tenoned. Strap bolts and through bolts figure largely as fastenings. Where these alone are not sufficient, straps of forms suited to the joints, and direction of joints of the beams are laid against faces and bolted through.

Numerous examples are grouped in **80–93**. Fig. **80** illustrates the shouldering of an upright between two horizontals. Fig. **81** is similar, with the addition of a diagonal strut, which rests on a horizontal. Fig. **82** is a diagonal timber: a chock fills in the end, and the whole is bonded and bolted together. Fig. **83** is a diagonal strut abutting on a step or straining-piece, and secured by bolts. The long bolts flanking the diagonal go up to a horizontal timber. Fig. **84** shows the detail of the other end of the diagonal fastening to the horizontal timber. Fig. **85** is another diagonal fastening made with long bolts. Fig. **86** is an intermediate tie securing a vertical to a diagonal member away from the end fastenings.

Fig. **87** shows horizontals and verticals fastened with a tenon and bolts, and a diagonal stub-tenoned; **88** is a right-angle fastening, tenoned and bonded with a strap bolted through; **89** shows uprights united to a horizontal with a joggled piece; **90** illustrates strutting attached with an iron knee; **91** crossing diagonals shouldered into the upright; and **92** and **93** show various crossing joints shouldered and secured with covering straps and bolts. These do not exhaust the joints possible, but scarfed and joggled forms, and the methods of making mortises and tenons, etc., are given in the course on CARPENTRY. The timber used for staging is usually deal or pitch pine.

Gantry Stagings. Gantries and stagings for travelling cranes, crabs, erecting towers, and for fixed cranes are used largely. The principles laid down are embodied in these. There are two principal types—the framed structure and the braced—and both kinds are made fixed or portable. Gantry framings of both kinds are shown with variations in the method of construction.

In the fixed type [**74** and **75**], which may be extended to any length, the work being an exact repetition of that shown, the cheapest style of construction is given. The various members are fastened with dogs. The verticals and horizontals are strutted, and diagonal struts afford stability at the ends [**74**] and sideways [**75**].

In the portable type [**76**], which has to be stable in itself, more care is taken with the joints and fastenings. On such end framings any superstructure can be raised, either timber beams for cranes or floorings. Strutting of these in a direction at right angles with the plane of the framings must be done, and if the beams are of considerable length they must be trussed.

The travelling wheels must have their axles carried in cast-iron bearings bolted to the timbers, and in heavy gantries provision must be made for travelling by toothed gears operated by winch-handles.

Derrick Stagings. When it is necessary to hoist materials to a great height, as in the erection of tall buildings, a derrick crane mounted on a high staging [**73**] is more economical than a gantry with a travelling crane. The kind of stage employed for this purpose consists of three built-up legs, one at each corner of a triangular base. The main one, known as the king leg, supports the derrick. The other two are termed queen or chain legs, and their function is to afford anchorages for the guys of the derrick.

These legs each consist of a square column of lattice-work formed by four vertical corner timbers, each of about 12 or 14 in. square, connected by horizontal and diagonal bracings. The king leg has a middle vertical timber, in addition to the corner ones, and is generally of larger dimensions than the queen legs, though all are of the same height. Owing to the great height, the vertical timbers have to be built up, either by fishing balks end to end, or by bolting a number of deals together and arranging them so that they break joint. A secure base of concrete or crossed balks must be prepared to erect this staging on. The legs are connected at the top by trussed girders, and below by diagonal timbers.

The legs are loaded with kentledge, either bricks, stones, or pig-iron. A chain is suspended from the extremities of the derrick legs, and is loaded near the ground. This prevents risk of overturning of the crane, or lifting of the back guys, which in ordinary cranes fixed to the ground is done by bolting them into the sleepers.

W. J. HORNER

Principles Underlying the Study of Animal Life. How Environment changes Functions. The Twelve Great Groups.

HOW ANIMALS ARE CLASSIFIED

Green plants alone are able to bridge the gap between the inorganic and organic worlds, by building up water, carbonic acid gas, and certain simple mineral compounds into living substance. Directly or indirectly, they constitute the food of animals, which but for them would starve and perish. They also prevent animals from vitiating the atmosphere to suffocation-point, for the breathing of animals rapidly uses up the free oxygen of the air and adds vast quantities of carbonic acid gas. Green plants breathe in exactly the same way, but on the other hand they absorb the carbonic acid gas for the sake of its carbon, and liberate free oxygen as a by-product of their feeding processes. The net result is the maintenance of the average composition of the air for an indefinite period of time. Were it possible suddenly to destroy all green plants, the whole animal kingdom would quickly die of suffocation.

The Survival of the Fittest. The question of evolution is fully dealt with in the course on Life and Mind, and has been also touched upon in the last chapter; but as its principles illumine and inform the study of animals at every point, a few remarks on the subject may be fitly made here. We now no longer believe that the innumerable species of animals were separately created, but hold them to have arisen by modification or evolution of pre-existing forms.

The rapid increase of animals, and the limited supply of food and standing room available, have resulted in a keen *struggle for existence*, much as may be observed in a crowded human community. And as individuals differ or vary from one another in greater or less degree, those best fitted to hold their own in this continual fight are most likely to survive and leave offspring to inherit their favourable characters. We have, in short, survival of the fittest by a process of what is metaphorically termed "natural" selection, as contrasted with "artificial" selection whereby the breeder and fancier have established varieties or breeds of all sorts of animals for the benefit or gratification of mankind. The unfit are ruthlessly eliminated, and disappear permanently from the world's stage.

Structural Adaptation of Animals. During the process of evolution, animals gradually become adapted to their surroundings or environment, using these words in the widest sense to include plants and other animals, as well as such things as land, water, air, and weather. It therefore follows that most, if not all, of the structural details of an animal have practical meaning, as we have already seen to be the case with plants. No better instance of this could be given than the mutual adaptations of flowers and certain insects. A monkshood blossom, for example, is so specialised in relation to the visits of humble-bees that a plaster cast of its interior closely resembles the body of such a bee. The tongue of the humble-bee, on the other hand, is of precisely the length necessary to reach the nectar in the monkshood flower. It is, in fact, abundantly evident that the course of evolution of the flower has been partly determined by the insect, which itself has evolved in part under the influence of the flower.

Every Animal the Solution of a Problem. A piece of machinery such as a waterplane embodies the solutions of a number of practical problems relating to flight, progression on the surface of water, and so forth. In the same way we may regard an animal as a very intricate piece of mechanism, embodying solutions to the problems of life in particular surroundings. The natural history of today searches out the why and wherefore of animal form and structure, which makes an occupation of vividly interesting kind. The colour-bands upon the body of a bee or wasp were once studied simply as a means of distinguishing between different species, and they are still useful for this purpose, but it is much more interesting to know that these bands are a case of "warning colouration" associated with unpleasant properties—the power of stinging, in this case—and thus serving as a partial protection against the attacks of insect-eating foes, such as some birds.

Vestiges of Former Functions. Animal surroundings are ever undergoing change, sometimes slowly, sometimes rapidly, so that evolution has always fresh problems to solve. It has often happened in the past, and will as constantly happen in the future, that this or that life-problem which has found a solution by way of modifications in structure ceases to be of importance. It is waste of force to retain parts of the body which are of no use under changed conditions, and they either have to find fresh work (change of use or function) or dwindle to insignificant vestiges (rudimentary organs). There is no doubt that the remote ancestors of land vertebrates were fish-like creatures, possessing a swim-bladder to help balancing in the water, as at the present day in many fishes. When the water was abandoned for the land, a swim-bladder became unnecessary, and by a series of gradual changes was pressed into the service of breathing, becoming the lungs.

A whale has no externally visible hind-limbs, but vestiges can be found on dissection. Long

ages since, no doubt, the ancestors of whales were land animals with properly developed hind-limbs. The change to an aquatic life had far-reaching results, one being the gradual dwindling of the hind-limbs to mere vestiges—souvenirs, as it were, of the old life on land.

The wings of insects have gradually evolved as adaptations to flight, and they are typically four in number. If, however, we examine a daddy-long-legs or crane-fly, we find but one pair of wings. Careful inspection will reveal the presence behind the wings of two little things like very short pins. They are placed just where hind-wings ought to be, and are doubtless the vestiges of such wings. It must not be assumed that vestiges are necessarily useless, and in this particular case the dwindled hind-wings probably have to do with balancing. An interesting example is afforded by Kerguelen Island, in the South Indian Ocean, which is so extremely windy that flight for feeble creatures like insects would often result in their being blown out to sea, to perish miserably. The insects of Kerguelen have got over this difficulty, for their wings have been reduced to vestiges that are of no use whatever for flying purposes.

Homology and Analogy. These useful words mean structural and functional equivalence respectively. Parts of two different kinds of animal which are in the same relative position and develop in the same way are said to display homology (or to be homologous), whether they do the same kind of work or not. The drum of the human ear, for example, corresponds to one of the gill-clefts or openings of a fish, but the use of the drum is to conduct sound, while the gill-cleft is concerned with breathing. There has clearly been a change of use during evolution.

Structures display analogy (or are analogous) when they do the same work, though they may be differently placed, and develop in different ways. The wings of birds and insects will serve as an example, for they are both used for flight, but the former are modified fore-limbs, while the latter are thin outgrowths from the wall of the body which have nothing to do with limbs. It often happens that structures are both homologous and analogous, as in the case of the wings of bats and birds, which do the same kind of work and are both modified fore-limbs.

Classification of Animals. As in plants, this means arrangement in groups, large and small, according to likeness and difference. Beginning with the largest, these groups are named successively: *Phylum* (or *sub-kingdom*), *class*, *order*, *family*, *genus*, *species*. We may take as an example the *phylum* of backboned animals (*vertebrata*), which includes a number of *classes*, of which the chief are mammals, birds, reptiles, amphibians, and fishes. Mammals are divided into numerous *orders*, one being that of the hoofed mammals (*ungulata*). This order, again, is subdivided into various *families*, of which we will select the horse family (*equidæ*), which is still further divided into *genera*. The most important *genus* is *equus*, containing all creatures to which the names horse, ass, and zebra are applicable. Each kind of these is a *species*. The ordinary horse, for example, belongs to the species *caballus*, and the domesticated donkey to the species *asinus*.

Scientific Names of Animals. As the common names of animals vary greatly in different countries, or even in the same country, it is necessary to give them scientific names, consisting of two words, the first referring to the genus, and the second to the species. Such names are mostly derived from Latin or Greek, languages which were at one time known to educated persons in all countries. Latin, in particular, once served as a kind of Esperanto, or common auxiliary tongue, and even now is used in writing some scientific works. Our chief legacy from these older times, however, is found in the double scientific names of animals and plants. By using its scientific names, zoologists of all nationalities can readily recognise and discuss any species.

Varieties and Breeds. A natural species sometimes includes still smaller groups called *varieties*, which differ less from one another than related species. The clouded yellow (*Colias edusa*), for example, is a British butterfly, possessing brilliant orange wings, with a broad, black border. There is, however, a variety of this called "*helice*," in which orange is replaced by whitish-yellow in the female insect. The full name of the variety is *Colias edusa var. helice*.

The variations of domesticated animals produced by a process of "artificial" selection are known as races, or *breeds*. Common examples are afforded by pigeons and fowls. Fantail, pouter, tumbler, Jacobin, carrier, and many other breeds of pigeons, though differing much in size and appearance, have all descended from the blue rock (*Columba livia*). The small Indian jungle-fowl (*Gallus bankiva*) is similarly the stock from which Indian game, Wyandottes, Orpingtons, Leghorns, Plymouth Rocks, Minorcas, and similar fowls have been derived.

Hybrids and Mongrels. To distinguish between species and varieties is a difficult and sometimes impossible task. As a general rule, however, crosses between true species, when procurable, are infertile hybrids. The typical example of this is the mule, which everyone knows to be a cross between horse and ass. In the case of varieties it nearly always happens that crosses—mongrels, as they are called—are completely fertile. But the distinctions indicated do not always hold, and probably varieties are simply species in the making.

True Aim of Classification. Various methods of classifying animals have been advanced from time to time, but the only one scientifically sound is classification by pedigree; that is, association together of forms which are actually related by blood. It was long ago realised that the most successful schemes of classification took a tree-like form, the great groups (*phyla*) corresponding to the main branches, and their subdivisions to classes, orders, and so forth. In the light of the evolutionary theory, this is easily intelligible, for the classificatory tree is, in fact, a genealogical one.

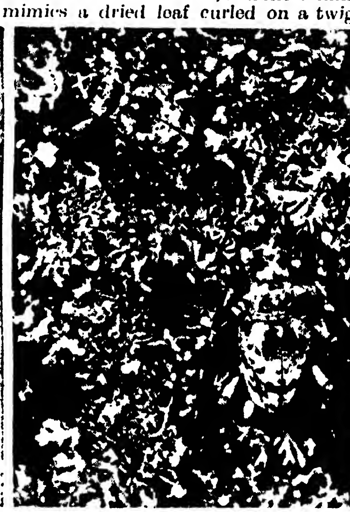
PROTECTIVE IMITATION IN ANIMAL LIFE

Tropical mantids which by their resemblance to bright flowers entrap butterflies and small insects.

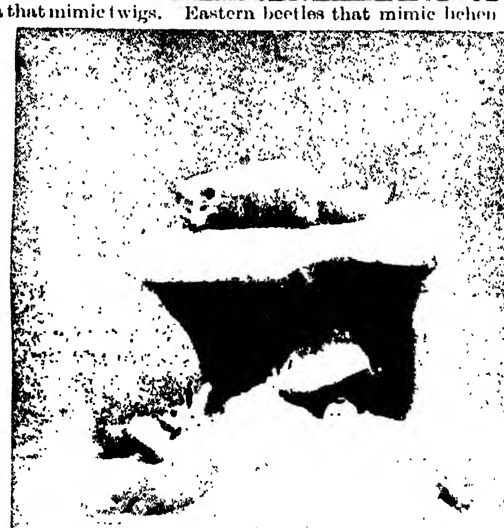
A Brazilian insect that mimics a thorn, and the comma butterfly that mimics a dried leaf curled on a twig.

An insect of Ceylon that mimics a leaf.

Insects of Uganda that mimic twigs.



Eastern beetles that mimic lichen



The summer dress and the winter dress of Arctic Fox, Ptarmigan, and Alpine Hare.

PLAN AND CLASSIFICATION OF THE ANIMAL KINGDOM

Twelve Great Groups. The vast majority of animals can be placed in one of other of twelve great groups, sub-kingdoms, or phyla. The appended diagram arranges these in the form of a tree, but our knowledge is too incomplete to do more than make a very imperfect attempt. A brief description of the twelve phyla follows.

1. BACKBONED ANIMALS—*Vertebrata.* The highest animals are here included, and are distinguished by the possession of a backbone (or its equivalent); a hollow, dorsal, central nervous system; and gill-clefts, which are always present during part of the life-history, though in the highest classes of the phylum they have nothing to do with breathing. For details, reference may be made to the course on BIOLOGY, which also summarises the ways in which backboned animals differ from other forms collectively called Backboneless Animals (Invertebrata).

2. SHELL-FISH—*Mollusca.* These include cuttle-fishes and their allies; snails and slugs; and bivalve molluscs (oysters, cockles, etc.), in which the body

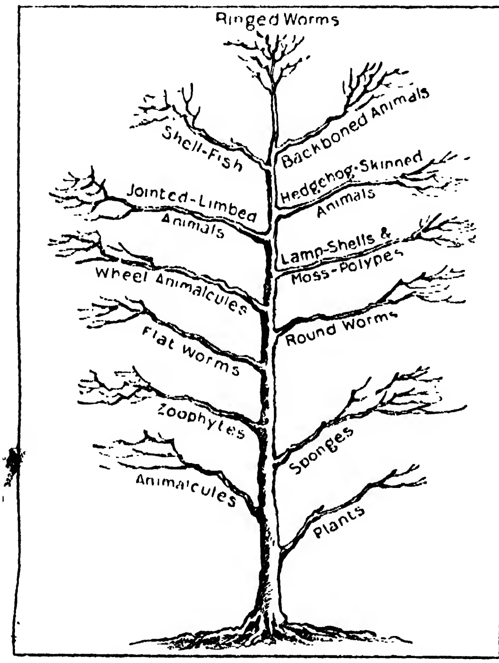


DIAGRAM OF THE TREE OF LIFE

is not divided into rings or segments, has a fleshy locomotor organ, or *foot*, projecting from its under side, and usually an external shell.

3. JOINTED-LIMBED ANIMALS—*Arthropoda.* This group embraces insects; scorpions and spiders; centipedes and millipedes; and crustaceans (lobsters, crabs, shrimps, prawns, etc.). In all of these the body is segmented, or divided into rings, or segments, of which a varying number bear jointed limbs. There is a horny external skeleton, sometimes strengthened by calcareous matter, as, for example, in most crustaceans.

4. RINGED WORMS—*Annelida.* This group includes a vast number of marine worms, as well as earthworms and leeches. Their bodies are segmented, and in marine worms the segments are provided with stump-like limbs, never divided into joints.

5. LAMP-SHELLS AND MOSS-POLYPES—*Molluscoida.* Lamp-shells appear to be distant and specialised relatives of the ringed worms, and possess a bivalve shell, which differs, however, from that of the bivalve molluscs. They are marine, as also are most of the moss-polypes, minute creatures that are almost without exception aggregated into colonies.

6. WHEEL ANIMALCULES—*Rotifera.* These are very small, transparent creatures, of doubtful affinities, which abound both in salt and fresh water, and are among the most attractive of microscopic objects.

7. ROUND WORMS—*Nemathelmia.* Here are placed numerous rounded, unsegmented worms, many of which are of a parasitic character, and may have a complex life-history.

8. FLAT WORMS—*Platyhelmia.* Most of the members of this group are flattened, unsegmented parasites—*e.g.*, tapeworms and flukes. They are chiefly notable as being the source of disease, while their life-history is often exceedingly complex.

9. HEDGEHOG-SKINNED ANIMALS—*Echinoderma.* This phylum is very clearly defined, and includes a large number of purely marine animals, of which star-fishes and sea-urchins are most commonly known. In the members of the preceding phyla the body is *bilaterally symmetrical—i.e.*, divisible into right and left halves, with a clear distinction between anterior and posterior ends, while the upper and under surfaces are more or less unlike each other. But in star-fishes and their allies, although the same kind of symmetry is traceable, it is more or less obscured by radial symmetry—a kind of regularity such as is seen in a wheel, star, or regular flower. The skin is strengthened by calcareous plates, which often bear spines.

10. ZOOPHYTES—*Cœlenterata.* Probably the most familiar members of this phylum are the beautifully coloured sea-anemones, which are to be found sticking to rocks between tide-marks, and when fully expanded well deserve their name of "sea flowers." Such an animal is essentially a living stomach, radially symmetrical, with circlets of tentacles surrounding a central mouth. Corals and jelly-fishes are other examples of the group. Nearly all zoophytes are marine, and many are in colonies.

11. SPONGES—*Porifera.* A simple sponge is a vase-shaped structure, with its walls perforated by numerous canals, into which flow currents of water bearing food and oxygen. The various products of waste are borne away by a stream that makes its exit from the mouth of the vase. Most sponges, however, form colonies of various and often irregular shapes. There is usually a calcareous, flinty, or horny skeleton, a good example of the last being afforded by the bath-sponge. With few exceptions, the members of the group are marine.

12. ANIMALCULES—*Protozoa.* This phylum embraces a host of lowly animals, the vast majority of which are minute or microscopic, and often difficult to distinguish from the lowest plants. The body of an animalcule consists of a single cell only, but this may be of a very complex character. Some of the slimy "oozes" which cover vast areas of the ocean floor are mainly composed of the calcareous, or flinty, skeletons of creatures of the kind.

Taking these twelve great groups of the animal kingdom in order, beginning with the highest, we shall be able to illustrate abundantly the main principles of Zoology, the chief difficulty lying in the great wealth of material.

J. R. AINSWORTH-DAVIS

Combination of Three Currents to Produce Revolving Magnetic Flux. Induction Motors. Stator and Rotor.

THREE-PHASE CURRENTS

WITHIN the last twenty-five years a system of electric supply has come into use under the name of *three-phase electric currents*, having certain special features and properties which have proved of great value.

Essential Features of Three-Phase. In describing, on page 1284, the properties of the alternating current, it was pointed out that in the periodic changes that occur the alternating current is of zero value twice in each period. Thus an alternating current of fifty periods per second dies down to zero a hundred times a second between the pulsations of the current. It follows that the flow of energy conveyed by such a current is pulsatory, not steady. This is analogous to that which occurs mechanically in any single-cylinder engine. There are two dead points in each revolution—where the crank has no leverage and the piston can exert no turning effort. Engineers get over this trouble by designing engines with two or three cylinders, requiring two or three cranks.

The three-phase system of currents consists in the employment of three electric currents, which are each alternating with the same frequency, and are of equal amplitude, but which, like the pistons of a three-cylinder engine, are arranged not to be in step one with the other, but to follow one another in regular succession. The reader already knows how the pulsations of an ordinary or single-phase alternating current may be depicted graphically, as on page 1288.

Numerical Illustration. As on page 1287, so here we may represent these alternating fluctuations numerically. Suppose a current that varies between a maximum of + 100 amperes and a negative maximum of − 100 amperes: then, if we consider the period as divided into twenty-four intervals, we may represent its successive changes during the period (lasting, say, one-fiftieth of a second) by the numbers given below.

First Half-period.

0	26	50	71	87	97	100	97	87	71	50	26	
	+	+	+	+	+	+	+	+	+	+	+	
	–	–	–	–	–	–	–	–	–	–	–	
0	26	50	71	87	97	100	97	87	71	50	26	0

Second Half period

The values during the second half-period are negative, the minus sign being printed above the figures that represent the successive values.

Now, in the three-phase plan, we have three alternating currents, their relations as to time being depicted in 119. In this diagram the three currents are named A, B, and C; and inspection of the diagram will show that if the time be represented by horizontal distances, each *period* being represented by an inch, then as the zero of the current that is in the B-phase is one-third of an inch to the right of the zero of that in the A-phase, it follows that the B-current is one-third of a period out of step (and later) than the A-current.

Similarly the current in the C-phase is another

118. A MUSICAL ILLUSTRATION OF THE THREE PHASES

one-third of a period behind the current in the B-phase, or two-thirds of a period behind that in the A-phase. But if we look a little further on in the A line, we see that the next period in the A-phase begins at one-third of an inch further to the right than the point at which the C-phase began. So the pulsations of the three currents come in regular succession, at times one-third of a period apart (like the recurrences of the three cranks of a three-crank engine or those of a three-throw pump), in the order, A, B, C—A, B, C—A, B, C, and so on.

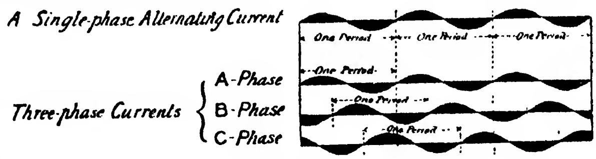
TABLE OF VALUES OF THREE-PHASE CURRENTS, ALTERNATING BETWEEN MAXIMA OF + 100 AND − 100 AMPERES

	Instant.	A-phase.	B-phase.	C-phase.
	0	0	− 87	+ 87
First Half-period.	1	+ 26	− 97	+ 71
	2	+ 50	−100	+ 50
	3	+ 71	− 97	+ 26
	4	+ 87	− 87	0
	5	+ 97	− 71	− 26
	6	+100	− 50	− 50
	7	+ 97	− 26	− 71
	8	+ 87	0	− 87
	9	+ 71	+ 26	− 97
	10	+ 50	+ 50	−100
	11	+ 26	+ 71	− 97
	12	0	+ 87	− 87
Second Half-period.	13	− 26	+ 97	− 71
	14	− 50	+100	− 50
	15	− 71	+ 97	− 26
	16	− 87	+ 87	0
	17	− 97	+ 71	+ 26
	18	−100	+ 50	+ 50
	19	− 97	+ 26	+ 71
	20	− 87	0	+ 87
	21	− 71	− 26	+ 97
	22	− 50	− 50	+100
	23	− 26	− 71	+ 97
	24	0	− 87	+ 87

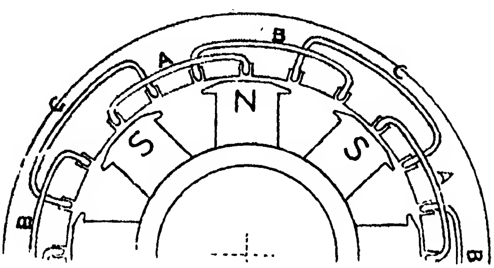
Musical readers will perhaps better grasp the idea of the way the three "phases" of the alternations overlap one another by an illustration attempted in musical notation with three simultaneous lines of notes in three-four time, as shown in **118**.

Numerically this is represented by taking the previous series of numbers, repeated three times, but each time shifted on by one-third of a whole "period" as shown in the table on the previous page.

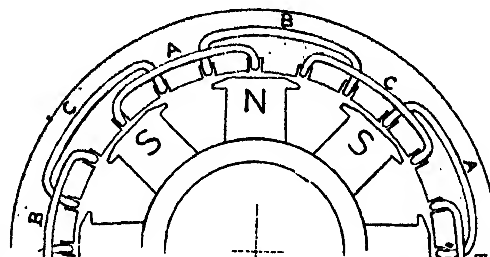
Three-phase Generators. To generate the three currents in these phasal relations to one another is quite simple. An alternator such as is described on page 1285 must have its armature wound with three independent sets of coils, an A set, a B set, and a C set, and they must be spaced out in the slots along the periphery of the armature at distances apart equal successively to one-third of the pitch from one north pole to the next north pole. Now, there are several ways of arranging the coils, according to the form given to the projecting end-bends. These are sometimes arranged, as in **120**, in three ranges; sometimes, as in **121**, in two ranges (one set projecting nearly straight out, while the other set is bent up); sometimes, as in **122**, where the bends overlap like wickerwork. They must, of course, be properly insulated from one another, and from the iron parts. The coils of the A-phase will all be joined up together to make the A-circuit, those of the B-phase will be joined up to form the B-circuit, and so forth. Sometimes the coils of each group are distributed in more than one slot per pole. Fig **123** illustrates a two-slot winding, in which there are therefore six slots per pole. Many large stationary armatures have a winding of this kind.



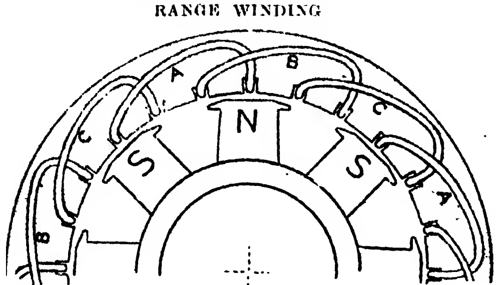
119. DIAGRAM OF PULSATIONS OF ALTERNATING CURRENTS



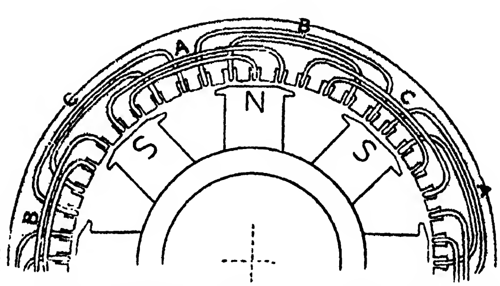
120. THREE-PHASE GENERATOR. THREE-RANGE WINDING



121. TWO-RANGE WINDING OF ARMATURE



122. THREE-PHASE ARMATURE WITH "BASKET" WINDING



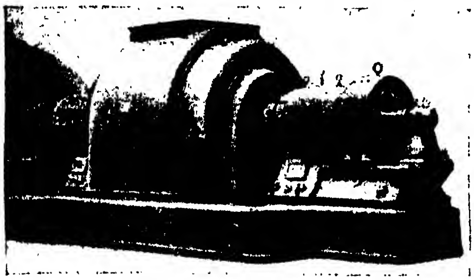
123. WINDING IN TWO SLOTS PER PHASE PER POLE

Almost all the alternators used in large generating stations are three-phase, and nowadays they are nearly always driven either by water-turbines where there is water-power available, or by steam-turbines where coal must be burned to raise steam.

Figures **124**, **125**, and **126** illustrate a 7500 kilo-volt-ampere generator, 25 cycles, 3 phase, 6600 volts, 750 revolutions per minute, supplied by the British Westinghouse Company to the London County Council. Fig. **124** shows the complete machine, Fig. **125** the rotating field magnet, and Fig. **126** the high tension stator. This machine is typical of modern practice, which is ever towards generators of larger outputs.

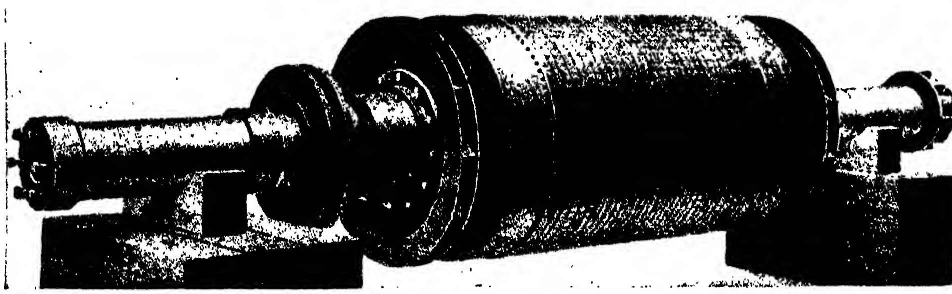
The Three Lines. From the generator there will go three lines to the place where the electricity is to be used; and every motor suitable for service on this system will have three terminals to be connected to the three lines. Lamps also may be used, and these (with due regard to voltages concerned) may be connected across either from line to line, or from each line to a common junction J as in **127**. No earth return or return line is needed; and if equal numbers of lamps are used in each phase, the

three currents will be of equal virtual value. The reason why no return line is needed is because each line in turn acts as a return line to the others. This is seen by reference to the table, which is drawn up for the case where each of the three currents is of the maximum value of 100 amperes, and where, therefore, the virtual value [see page 1287] of each of the three currents is



124. 7500 K.V.A. TURBO GENERATOR

70·7 (or say 71) amperes. Looking, for example, at line 6 of the table, we see that at the instant when 100 amperes are going out along line A, the value in B is −50, and in C is also −50 amperes, so that the lines B and C are, at that moment, each bringing 50 amperes back to the generator.



125. MODERN TURBO-ROTOR ROTATING FIELD MAGNET

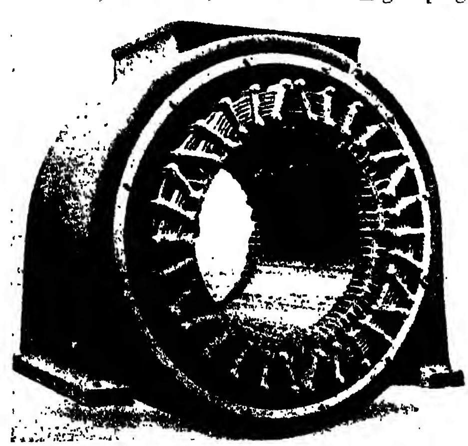
A moment later, when the A current has dropped to 97 amperes, 26 amperes will be coming back by the B line, and 71 by the C line; while at the next moment (instant No. 8) the 87 amperes are going out along the A line, the whole 87 coming back by the C line, and so forth.

Connecting up Three-phase Windings. There are two principal ways of connecting up the three windings. In the way called Y-grouping, or *star-grouping*, the three circuits start from a common junction J, as in **128**, and their three ends go to the three lines. In this case, the voltage between any two of the lines is equal to $\sqrt{3}$ (that is, to 1·732) times the voltage generated in any one of the three circuits of the generator, and the current in each line is the same as the current in each circuit. In the other way, called Δ-grouping (delta-grouping), or *mesh-grouping*, the three circuits are joined up with the beginning of one coil to the end of the next, as indicated diagrammatically in **129**, and the three lines are joined to the three meeting-points. In this case, the three voltages between the lines are the same as the voltages generated in the three circuits, but the line currents are now each 1·732 times as great as the current in each circuit. Thus, suppose a machine to be designed with so many turns in each armature circuit as to generate 1000 virtual volts, and of such a thickness of copper conductor as to carry 100 virtual amperes at full load, then, if the Y-grouping were adopted, the lines would receive 100 amperes each, with 1732 volts from line to line; while if Δ-grouping were adopted, the lines would receive 173·2 amperes each, with 1000 volts between the lines. In both cases the output will be 1000 × 100, that is, 100,000 volt-amperes, or 100 kilo-volt-amperes for each phase, that is, 300 kilo-watts [p. 1289], if the currents do not lag.

Three-phase Conductors. Where the lines are carried overhead for transmission of the current, it is usual to carry them on three insulators arranged as at the corners of an equilateral triangle. For underground conductors, cables are used, having three separately insulated cores, as shown in section in **130**.

Three-phase Transformers. To transform three-phase currents from a high voltage down to the low voltage needed for lamps or motors, we may employ either three similar transformers—one in each phase—or else a special three-phase transformer having three sets of primary windings, and three sets of secondary windings. Such a three-phase transformer is shown in **131**.

The three windings of each side may be connected, as desired, in either Y or Δ grouping.

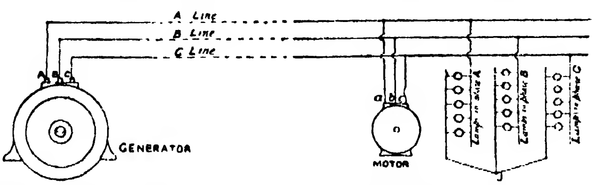


126. STATOR OF 7500 K.V.A. TURBO GENERATOR

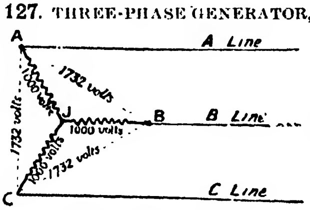
Three-phase Motors. The great reason for adopting the three-phase system is its suitability for driving three-phase motors; for by suitably combining coils in an armature or stator the interaction of the three currents produces a rotating or progressive magnetic field, and a suitable rotor placed in this field is set powerfully into revolution without the need of connecting it in any way into the circuit. We shall be helped to understand how this comes about if we regard **132** to **134**, and compare them with the table of values given above.

Revolving Magnetic Field. Suppose an armature wound with three sets of coils laid in slots, just as shown in **122**, those coils being in three phases, A, B, and C. Now, suppose that at the moment under consideration the current is at its maximum—say, 100 amperes—in the A coils. At that moment, as seen from the tables, the currents in the B and C coils will each be − 50. The arrows [**132**] show the direction, + being a circulation to the right, − to the left. Then, the circulations of these currents will conspire to produce a magnetic field which will be strongest right under the middle of the A coils. An instant later, the A-current will have died down to + 97, while the B-current will have become − 26, and the C-current − 71. This will have the effect of shifting the resulting magnetic field a little to the right. After another instant, A will have died down to + 87, B will have become 0, and C will be − 87, and the magnetic field will have shifted a little further. This is shown in **133**. At a later stage, A will have become + 50, B will be + 50, and C − 100, and the flux, which at first was under the middle of A, will now be a whole tooth to the right, as in **134**. When A has reversed to − 50, B will be + 100, and C will be − 50, and by that time the magnetic field will have shifted so that the strongest part of it will be under the middle of the B coil.

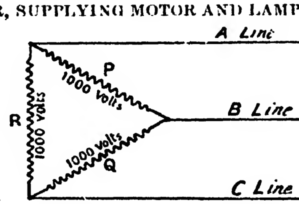
The Stator. In this way, though the stator and its coils stand still, the effect is produced of a revolving multipolar magnet. The magnetism revolves, though the metal framework stands still. Such a field is sometimes called a *Ferraris field*, in honour of Galileo Ferraris, who first showed how, in such a field, rotation is produced. Fig. **135** depicts the stator of an eight-pole three-phase motor. Any mass of metal placed in a revolving magnetic field tends to revolve round after the field by reason of the electric currents induced in it by the invisible magnetic lines as they sweep round it. Hence if a rotor or revolving part be provided, consisting of an iron core having closed coils embedded in its periphery, it will, if inserted in this



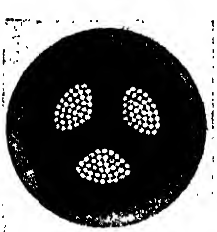
127. THREE-PHASE GENERATOR, SUPPLYING MOTOR AND LAMPS



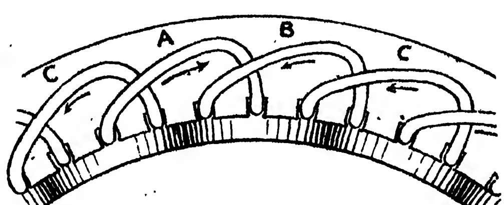
128. THREE-PHASE Y-GROUPING



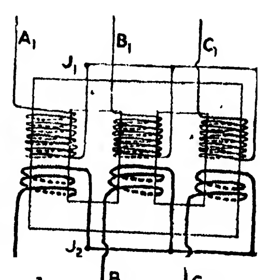
129. THREE-PHASE Δ-GROUPING



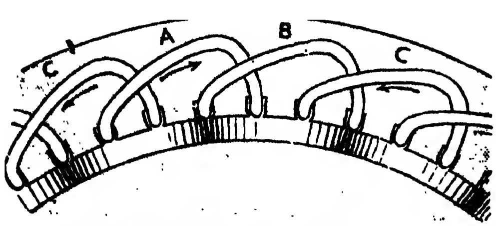
130. THREE-PHASE CABLE (SECTION)



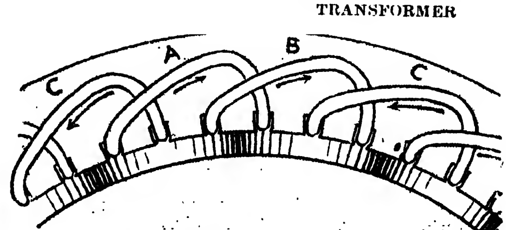
132. MAGNETIC FLUX DUE TO THREE-PHASE CURRENTS, CASE I



131. THREE-PHASE TRANSFORMER

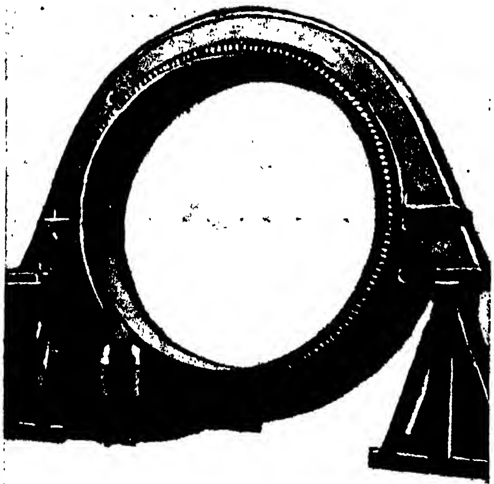


133. MAGNETIC FLUX, CASE II



134. MAGNETIC FLUX, CASE III

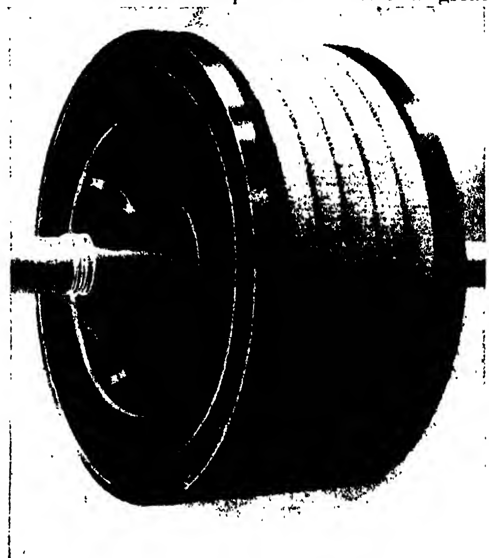
revolving field, be driven by the currents induced in it. As the revolving part of such motors receives its currents by *induction* instead of conduction, and is entirely disconnected from the primary circuit, such motors are often called *induction motors.*



135. STATOR OF 750-H.P. SLIP-RING INDUCTION MOTOR FOR WINDING GEAR

The Rotor. For small motors, the suitable rotor to put into such a field is such as that depicted in **137.** On a simple shaft is mounted an iron cylinder, built up of discs of sheet iron, in the periphery of which are embedded a number of copper rods or conductors, all joined together at each end. Such a construction is described as a *squirrel-cage* rotor. It needs no connection to the outside circuit, but receives its currents wholly by induction. In fact, the action is much like that of a transformer, the stator coils acting as a primary winding, and the bars of the squirrel-cage acting like the secondary coils. The squirrel-cage runs round, always trying to overtake the revolving magnetism, but never succeeding. In fact, it runs some three or four per cent. slower. This difference of speed, expressed in percentage, is called *the slip.* At no-load, the slip is less than one per cent. As the load on the motor is increased, the slip increases, the driving forces being proportional to the slip. Motors with squirrel-cages, though so very simple, do not exert any great torque, or turning effort, at starting.

Wound Rotors. For all cases, therefore, where a motor is required to exert a great starting effort, the rotor is of a different kind. The iron core is provided with slots in which is wound another three-phase winding, the ends of which are connected to three slip-rings mounted on the shaft, as in **136.** On each slip-ring a brush makes a sliding contact, so that connection is made with three sets of resistance-circuits. The effect of thus introducing resistance into the rotor is to increase the starting effort. But as the resistance wastes some power by growing hot, arrangements are made to cut it out as soon as the motor has started, and in running on load the rotor circuits are simply closed on themselves.

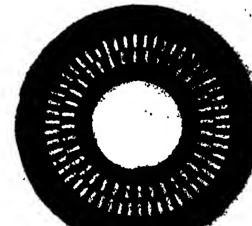


137. ROTOR OF INDUCTION MOTOR

Fig. 135 is from British Westinghouse Co., and Fig. 137 is from Bruce, Peebles & Co.

136. WOUND ROTOR OF INDUCTION MOTOR

By courtesy o Messrs. Willing, Eborall & Co.



138. STAMPING FOR INDUCTION MOTOR

The bodies of three-phase motors are constructed of stampings [138] of thin sheet iron or mild steel about one-sixtieth of an inch thick. The slots for the windings are stamped out at their peripheries.

SILVANUS P. THOMPSON

Scale Playing—continued. Chromatic Scales. Rhythm. Accents. The Pedals. The Importance of Practising the Old Masters.

PHRASING

Scales in Double Thirds. Scales in double thirds can be fingered on this same principle of *two* groups to the octave, thus:

1 2 3 1 1 2 3

although many finger them in three groups, thus:

3 4 5 3 4 3 4
1 2 3 1 2 1 2

For such three-group system the student may be referred to Leopold Waldstein's "Scales in Double Thirds and Sixths." We had better, perhaps, omit the study of double sixths; they are dangerous for the hand, unless practised very carefully, and are not very profitable. The two-group system of double thirds as taught and formulated by Mr. Matthay is given below. Note that the groups of four begin with twice thumb or "double-thumb" position, as we shall call it.

1. All white keys, excepting F and B, like C, counting from key-note:

C { 3 4 5 2 3 4 5 / 1 2 3 1 1 2 3 } { 3 2 1 3 2 / 5 4 3 2 }

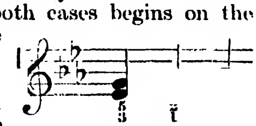
Hands *coincide* as to fingering position.

The exception, F, is like C, but begins with "double-thumb" position, instead of the "five-finger" position.

2. B has "all-black" keys position—*viz.*, index finger of both hands in the "double-thumb" position falls on the middle black key of the three, thus:  whilst the combination (3/5, which occurs *twice* in the octave, *always* falls on the two black keys with the big gaps between them, thus: 

Note that the R.H. (3/5 and L.H. (3/5 coincide in the two hands twice in each octave. This fingering applies to the other "all-black" keys—*viz.*, F♯ and C♯, and also to the minors of B and B♭; but in the case of these minors the index finger falls on the *white* key inside the three blacks.

3. In E♭ and B♭ major the "double-thumb" position in both cases begins on the second note of the scale with its accompanying upper third. Hands coincide as in C. These are all the majors, with the exception of A♭, which we shall take with its tonic minor.



4. All minors, with the exception of G♯ minor, C♯ minor, and F♯ minor, are fingered like their tonic majors. The left hand of F minor is also an exception, and is best fingered like C:

3 2 1 3 2 1 1
5 4 3 5 4 3 2

The rule for the set of three minors is double-thumb *on* the notes of the augmented second in both hands—*i.e.*, the repeated thumb occurs in both hands on the sixth and seventh of the scale. A♭ major takes the same fingering as its enharmonic minor—*viz.*, G♯. The (3/5 (3/5 coincides only once in the octave now with the two hands.

Chromatic Scales. Chromatic scales in single notes are fingered normally, thus (beginning on C♯):

3 1 3 1 2 3 1 3 1 3 1 2
one octave.

or: 3 1 2 1 2 3 1 2 1 2 1 2

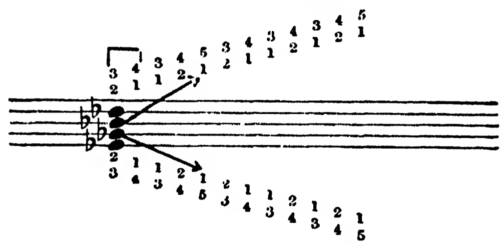
Chopin used also other methods, thus (again beginning on C♯):

3 4 3 4 5 3 4 3 4 3 4 5

and Busoni, the present-day Italian pianist, thus:

3 4 3 4 5 2 3 4 5 3 4 5

Chromatic scale in double thirds, thus:



Playing them thus by contrary motion on the *keyboard*, the action of the *hands* is exactly the same, the fingering of both coincides. The inside part of both hands has thumb on all the white keys and forefinger on all the black.

In all double-note scales the legato can only be produced at the finger-group junctions by *one* of the pair of notes; we must realise this, and rest gently on that particular one, gliding easily to the position of the next pair.

Chords and Arpeggi. The fingering of chords and arpeggi next claims our attention. The normal fingering for the three positions of the common chord in arpeggi is first position (root position), 1 2 3 5; second position (first inversion), 1 2 4 5; third position (second inversion), 1 2 4 5—these when the first key of the group is an ivory. The exception comes when in the second and third positions the distances on the keyboard between fourth and fifth fingers is greater than usual, as, for instance, when the interval of the third then lies between B♭ and D or E♭ and G, the middle finger may be used instead of the weaker (fourth) on the black key. But if the hands be large, and the stretch between the fingers ample, it is better to make it a rule to use the *weak* finger here. It makes

for uniformity, and prevents the over use of the strong finger and under use of the weak.

When in an arpeggio the position of the chord offers us a *black* key for the starting point, it is better to postpone the use of the thumb till the first white key is reached in going away from the centre of the keyboard. When we play the arpeggi of F♯ major and E♭ minor, we are obliged to use the thumb on the black keys, as these chords consist of black keys only, the black keys here being treated as if they were all white ones. The normal fingering of chords of the seventh is: 5 4 3 2 1.

Here, again, when these are taken in arpeggio and begin with a black note, postpone the use of thumb in travelling away from the centre till the first white key after a black key is required. It will be found easier always to make the pass under take place between a black key and a white. In fingering chords which include two adjacent keys, both white or both black, the thumb should be used on the two adjacent keys, thus:

Remember, when uncertain as to the fingering of a passage, first to try to find the finger-grouping. We may also try it in the other direction—*i.e.*, if an ascending passage, finger it from the top downwards, and vice versà, so that we may discover what is the best finger-grouping.

Fingering Sequences. When rapid passages consist of repetitions of the same figure, it is best to finger these all like the first group of the sequence, regardless of the unevenness of the keyboard caused by black and white keys; but this is not obligatory. Fingering chosen must be such as helps to make the phrasing clear, and it depends also on *how* the passage is to be played—whether by finger-movement, hand-movement, or arm-movement, staccato or legato, and so on.

Chopin is fond of playing soft chromatic *marcato* successions of notes from the arm, and for this purpose has a curious but effective fingering—all white notes with the fifth, all the black notes with the fourth finger. See, for instance, the ornamental passages in the well-known E♭ Nocturne. In playing passages thus, turn the hand laterally somewhat, wrist inwards, so that the two fingers (fourth and fifth) could be dragged along over the keys—fourth on the blacks and fifth on the whites. Again, Chopin joins his arpeggi passages occasionally by a smooth lateral movement of the forearm, instead of passing over or under the thumb. All these fingerings seem quite natural when the *muscular conditions* are correct.

Fingering in its details is a variable quantity—what suits one hand and mind may not suit another; but the main rules as to looking for *grouping* always apply. It is well to try the fingering suggested by, say, a Von Bülow in the later Beethoven sonatas, or a Klindworth in Chopin's works, before resorting to one of our own; and also to compare fingerings, and select, if we can find different editions.

Fingered Editions. In choosing fingered editions for study, we should never choose those (like Charles Hallé's) that finger *every* note. Nothing is more confusing. The numbers placed above or below the notes should be applied only as guides to the groups of fingering or indications of something unexpected. One should regard them as danger-signals or finger-posts. Thus, one will welcome them as friends and not disregard them as bores. As teaching and self-teaching editions, I would recommend the German "Cotta" editions of the classics—*i.e.*, Clementi, Haydn, Mozart, Beethoven, etc.; Peters' *Kroll* edition of Bach; the Bote and Bock edition of Chopin; and Madame Schumann's edition of Schumann's works. Matthay's "Popular Teaching Pieces," a selection mostly from the earlier composers, as Scarlatti, Paradies, Bach, etc., supply material of the very best for serious students. Here I would urge that all teaching of fingering should now be based on the 1 2 3 4 5 notation and *not* on the × 1 2 3 4, for the very good reason that the cheapest and best and all foreign editions adopt the first mode. Pianoforte music when first published appears, as a rule, unfingered, but fingered editions soon appear if the works are popular; and Germer has done a good deal of the finger editing of such modern composers as Grieg and Tschaikowsky. Siloti, the Russian pianist, has done the same for many of the composers of the Russian school whose music it has been his mission to popularise.

We may have learnt to get out of the instrument all it can give; our tone-production and agility may leave nothing to be desired; yet, unless we learn to phrase well, we shall be incapable of giving musical pleasure to anyone.

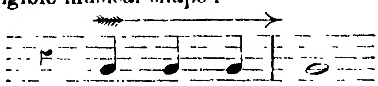
Phrasing. By phrasing we mean the conception and execution of notes as intelligent and intelligible utterances. Music is at all times an intelligent and, as a rule, also an emotional utterance, and unless we understand what we have to play, alike intellectually and emotionally, our technique will be a useless accomplishment. For the intellectual grasp of the larger forms, much study and much hearing of music is necessary. For emotional sensitiveness our own temperament must be answerable. To be a good reproducer one must be first a sensitive plate oneself—the music must have affected us strongly before we can affect others by our rendering of it.

Although using the keys with intention and intelligence, we can give expression only to what we ourselves have felt and seen. The reproduction of a work of art is such a delicate operation that *all* our attention is called for, *every* time we attempt it, for every note we play.

Artists say it is practically impossible to reproduce a "Venus de Milo" in marble, and yet this is the sort of thing we pianists attempt every time we try to play a Sonata Appassionata, for example. We may learn much of the generating causes of musical expression by reading such books, which are cheap and accessible, as Bertenshaw's "Musical Form," Riemann's "Musical Æsthetics," Lussy's "Musical Expression," and Carpé's "Rhythm and Phrasing."

Riemann, for instance, shows how music, in the very nature of things, expresses our feelings—that the pulse in music, for instance, is analogous to our own pulse—the crescendo and accellerando the natural expression of the human body under the influence of mental excitement, the decrescendo and diminuendo as naturally that of recurring languor. Besides this, music can be "realistic" and imitate things outside of us—things that we see or hear.

The Importance of Rhythm. Much of this tone-painting is achieved by rhythm. We must see to it in our performance that this rhythm shall be *alive*, shall always be freshly *willed*, shall never sink into mere automaticity. We should at all times strongly picture to ourselves the intended rhythms, even in mere scraps of technical exercises, seeing to it that even such a simple scheme as this shall have an intelligible musical shape:



Out of such a fragment Beethoven made his C Minor Symphony. Let us even feel that finger exercises are possible fractions of some great whole.

Where Riemann theorises, Lussy lends immediate practical aid, and is full of examples. He treats of the various kinds of accents—the metrical, grammatical or bar accents; the rhythmical or phrase accents; and the rhetorical or pathetic accents.

In his "Introduction to the Elements of Music," Niecks (best known as Chopin's biographer) says: "The phrase accent sometimes modifies and even altogether sets aside and reverses the bar accent." For the phrase groups bars together, and we cannot very well *group* or unite them if we constantly disconnect them by an *equal* emphasis on the strong beat of each. To make musical shapes definite and musical utterances articulate, we may use either a complete disconnection of tones, a momentary silence (often too short to be even indicated by a rest), or a partial disconnection got by accentuation.

We must keep always before us a vivid mental picture of the phrasing, and *listen* to our own performance, that in it we may *realise* this picture. But the thing to be kept chiefly in mind is that every musical phrase *goes* somewhere, that a group of notes means nothing musically until it is, by accentuation, made to point to a climax, a phrase-object, found, as a rule, towards the end of each. "We must learn to perceive," as Matthay says in his "First Principles," "what the music does, where it is that each idea, phrase, sentence, and section has its natural climax or crisis." As, for instance, the opening bars of Chopin's E♭ Nocturne:

Simple melodic waltzes, with an easy, throbbing accompaniment, make excellent early studies for the purpose of acquiring such rhythmical or phrase sight, and also for the study of tone-quality and tone-quantity as contrasted in melody and accompaniment. Study such waltzes before attempting the art waltzes—the Chopin waltz, for instance—which get many of their effects by deviations from the normal by the unexpected. We must learn rigidly to obey the law before we can take an artist's licence with regard to it.

Accents. In playing strongly accented notes, let our artistic and our technical judgment both be on the watch, the one seeing to it that the accent is neither stronger nor weaker than is justly due, the other that we guard against (1) using down-arm force, (2) pressing on the keyboard after we hear the sound begin.

Accents and all marcato effects are pitfalls in this respect. We must resist the natural tendency here to use down-arm force, the finger and hand must act *upwards* against the loosely lapsed arm. The unexpected should, as a rule, be well marked; syncopated notes, therefore (deviations from the natural metrical accent), and chromatic notes (deviations from the diatonic scale), unless the latter be mere unaccented passing notes, call for an accent. Discords are intended to arrest the attention—some musically nonsensitive people play the most poignant discords as though they were as innocuous as the tonic triad. Mentally follow the resolutions of discords in harmonic progressions, and learn, in playing chords, to bring out now one note and now another to this end. To effect this, allow the finger that is to bring out a particular note of the chord to take more weight than the others.

In chord playing from the wrist, the fingers must take up the position relatively to the hand before it descends. To this end we must learn to *mentalise* all the fingers that are to be used in the performance of a chord before we fulfil the act of playing it.

Full chord playing is an important department of modern pianoforte work, and must be specially studied. We must learn to play full chords with loose-arm weight behind the fingers—a consideration which we have already studied—and, when required legato, connect them as closely as possible by beginning the lateral arm-movement while the hand and fingers are still, as it were, lazily lying on their keys, the pedal being used to make the actual tone continuation—this for the interpretation of such passages as the hymn-like chorale middle section of Chopin's Nocturne in G Minor. Here we have an invaluable study in chord phrasing. Connect the chords in groups of eights by the rhythmical balance of the accents and also by the tone.

The Use of the Pedals. This brings us to the use of the pedals. To a passage of this sort we may apply what is called the "syncopated" pedal. The general rule as to pedalling with the damper pedal (the right foot pedal) is that we may depress it, and keep it depressed, as long as the harmony of a passage does not change. When the harmony changes we must lift the foot and release the pedal, instantly re-depressing it if we wish a continuous pedal effect. For detached chords the pedal may be depressed at the same moment as the keys, but in the course of a legato passage the finger and foot must not go down simultaneously. On the contrary, the pedal must rise just as the next keys are being depressed, immediately going down again, however, to continue the new sounds. This "syncopated" pedalling *joins* the sounds without allowing them to overlap. If foot and finger rose *together* there would be a short silence between the sounds.

This syncopated pedalling may be applied to every note of a melody or every chord of a harmonic progression, such as the above-mentioned Chopin chorale. Such constant pedalling in great portions of modern music is absolutely essential, but we must not lose sight of the great importance of *omitting* the pedal at other times. Many players of to-day over-pedal, thus losing the advantage to be gained by the contrast between pedalling and its total cessation. Chopin without the damper pedal would be like a Whistler picture reproduced in the style of Sir Noel Paton. Schumann was a still greater devotee at the shrine of the damper pedal; he did not care about harmonic exclusiveness, he liked to put down the pedal and to keep the course of harmonic changes in unbroken legato—too much so very often, in fact, and the pedalling marks in many of his works requise much revision. Chopin was much more refined in his use of the pedal, probably because he was a better pianist. Mendelssohn was ultra-refined, and we must bear this in mind in playing his music; let his outlines be definite, his colours pure, his rhythms free from emotional exuberance; try particularly to be "good," as he himself puts it, and refrain even from a self-indulgent rallentando at the end of a composition.

Use of the "Una Corda" Pedal. The "una corda" pedal should be used sparingly. Modern composers, as a rule, indicate the use of it, as, for instance, Grieg in his well-known Lyric pieces. Very frequently it is used in combination with the damper pedal; the two are quite independent. Use both pedals very sparingly, if at all, in performing the music of Scarlatti, Couperin, or Bach. The first two composed for the harpsichord, and even Bach's clavichord, although it did possess some sensitiveness of touch, was not much like a modern piano.

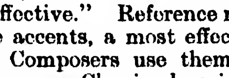
Part Playing. Much modern pianoforte music consists of a melody with accompaniment. We must listen to the *end* of each melody note as much as to its beginning, in order that we may join it perfectly to the following melody note, and that we may choose the right tone for this succeeding note. To bring out the melody also, we must be careful to *subdue very much the accompaniment*, and not let our attention to the *phrasing* of the *melody* be distracted by the accompaniment. If the melody be at the thumb side of the hand, as in Schumann's beautiful Romance in F♯, and in many popular waltzes, remember the use of the rotary relaxation there; if at the little finger side, as more frequently happens, we must see to it that the forearm rotary relaxation helps the weak fingers at that side. Have a melodic ideal ever present—imagine such melodies given out by the 'cello, the violin, or the voice, and imitate these. When a note is sustained while other notes play round it, *listen to the sustained note to the end.*

It is not enough merely to keep the key down; we must connect the sustained tone intelligently with that which follows it in its own part. Practise Bach for such part playing, the playing of several melodies one above the other—his melodies are more difficult to perceive and more difficult to connect subtly than even Chopin's—and listen to all the interwoven parts.

Crescendo and Diminuendo. A perfect crescendo or diminuendo, especially if long sustained, is seldom heard, and yet they are among the most entrancing and convincing of musical effects.

The crescendo in performance was not introduced till late in the eighteenth century, in the orchestra at Mannheim; and when the audience first heard this new effect, it is said they rose from their seats like one man. Realise the emotional possibilities of *nuances* (shading). The secret of getting a good crescendo is, as Von Bülow, the cleverest and wittiest of nineteenth century pianists, puts it, "when you see the expression mark 'cres.' play softly, when you see the mark 'dim.' play loudly." This gives us something to work away from, and prevents our making the common mistake of *at once* playing louder at the beginning of a crescendo, , or softer at the beginning of a diminuendo, .

The same thing holds of accelerations and retardations of time. Accelerando must be gradual and continued, as must ritardando. It is different in the case of ritenuto, which is a *sudden* slackening of the tempo. It requires all our attention to keep an accellerando really accelerating to its climax, and a ritardando really slackening note by note till all animation dies out; "and we must remember," says Mr. Matthay, "that all such effects, both of tune and time, must increase with an increasing *ratio* to be effective." Reference must be made here to time accents, a most effective means of expression. Composers use them in the form of syncopations, as Chopin does in his waltzes:



Time Accents. In performances we can make a melody note *seem* accented by making

it either slightly longer than is due or letting it begin just a very little too late. We may also delay a little the entry of the accompaniment *after* a melody note which we wish to make specially prominent, and then, by hurrying the time a very little, make up for this irregularity. This is the principle of the tempo rubato, which even Mozart employed in a measure, as we learn from his letters, and which must be applied to all modern music since the time of Chopin and Liszt. These two pianist composers were the great protagonists of the tempo rubato, or robbed time.

Although seemingly whimsical and wayward, it is really rooted in a strong sense of rhythmical balance, and Liszt compared it to a tree firmly rooted in the soil, whose branches were yet played upon by the wind. Only those who are anchored to a perfect feeling for rhythmical balance and symmetry can safely trust themselves to the waves of tempo rubato. It takes effect in prolonging some notes, hurrying others, dragging one part of a phrase, accellerating another, either dragging or accellerating a series of phrases and making up for it with the remainder of the period; but, whatever form it takes, it should always be so perfectly balanced that the period ends where the strict metronome beat *would have had it end* had the time never been bent from the straight line. Without the tempo rubato, the music of Chopin would be vulgarised, and much of Schumann rendered unintelligible; but we must beware of applying it to any extent to the earlier composers, as Haydn or Schubert—it would destroy the meaning and symmetry of their music.

Ornamental Notes. It is a mistake to hurry the rendering of ornaments—in cantabile music we should see that we *sing* them. Let them be *grace* notes in very truth, and let them always heighten the particular beauty, and intensify the special character, of the music they adorn.

Quick, light ornaments should be played with as little weight as possible, remembering that such are in truth agility passages of short duration, and that the touch laws for agility must therefore be obeyed in them. Do not (as so many are apt to do) lift away the weight of the hand in preparing for this. Most delicate finger-work, other than pianoforte playing, requires, possibly, that the hand should support itself by its own muscles, and so, instinctively but wrongly, the inexperienced player prepares for a delicate passage by lifting away the weight of the hand. Such a proceeding is fatal to ease, certainty, and beauty of tone. As already pointed out, we must let the hand lie on the fingers, and see that it makes no exertion of any kind in such light passages. "Prepare" such a passage with as many fingers as possible, feel the resistance of keys, let the loose, light weight of the hand *lean* against the keyboard, then imagine the whole group as one concept—not conceiving each note singly—thinking only (if it be a long passage or cadenza) of the notes that form the landmarks of the passages and the fingers that fulfil these "landmark" notes, and leave all the rest to subconscious automaticity.

See that we breathe deeply, fully, freely before starting on one of these long embroideries, such as occur, for instance, in Chopin's Berceuse, and keep the whole body passively quiet meantime, as the least thing will disturb us in the execution of such fairy-like webs of sound. *Holding* the breath through difficulties and subtleties of this kind is a bad habit to fall into. See to it that we use either what Mr. Matthay calls "passing-on touch," or first species, or perhaps second species for the louder portions, and make sure of the preliminary and continuous resting. Let no excitement and nervous tension communicate itself to the upmuscles of the hand, and so cause it to become active to the extent of lifting away its own weight. Then, with a clear mental picture of what we want to produce, "the rest shall be added unto us." To ornaments, as to melodies, the tempo rubato may be applied; shakes may be begun slowly, accelerated towards the middle, and slackened off again towards the end.

Beethoven's Influence on Technique. When sufficiently advanced, we should make not only Bach but Beethoven our daily bread. He will force us to give attention to the music, and to develop a varied tone-palette for its expression. We cannot lazily dream through a Beethoven sonata after having once mastered the art of touch-variety. He expects so much from us, and his expression is often so unexpected, that there is no moment during his music when we may cease to be acutely alert, alike musically and instrumentally. Judging the due amount and quality and time-place of every note from start to finish, and watching key-resistance to see that we realise it, we must get a fine loosely-left arm and well-braced finger and hand for his frequent sforzando staccato chords, and give them with a convincing, well-nourished tone, or sharp finger-action instead, as the case may require. We must learn to obey his characteristic crescendo followed by a sudden piano, and learn to change our technique as suddenly as *he* changes his mood, from the passionately virile to the passionately tender.

From the moment of reading out a Beethoven sonata we should try to "paint" it—that is, try to play it with the constantly changing touch-varieties required. We must not say, "I shall get the notes first and then see what they mean," but look for the meaning through the notes by obeying them in every particular from the first. We should not begin the serious study of Beethoven till we *can* proceed thus. Of course the bravura work—the difficult passages and presto movements—will require to be worked at out of focus, but try even when working at these to conceive their place in the finished scheme. Remember that we never can express all there is in such music unless we obey the laws of tone-production, but remember also that artistic reproduction is the art which conceals Art, which is the goal of all technical study.

M. KENNEDY-FRASER

The Construction and Equipment of Cotton Mills. Cleaning, Carding, and Other Processes in Spinning.

COTTON SPINNING

The standard type of cotton-spinning mill in this country is an edifice of four storeys, brick-built, with a generous window-space [1]. In order to minimise the vibration of machines, the construction is solid. Cotton being inflammable and spun in heated atmospheres, the mills are made fireproof, and their ceilings are fitted with water-sprinklers.

Equipment of Cotton Mills. The upper floors are supported by pillars, and constructed of steel and concrete, or arched brick and iron, covered by boards. The modern style of building is somewhat ornamental externally. The rooms are light, lofty, and of the full size of the floor. They are approached by stairways set in a built-out tower, and fitted with emergency exits in case of fire. The premises are under the close supervision of the factory inspectors, who supervise the ventilation, cleanliness, hours of labour, and the fencing of machines.

The spinning-mills are driven almost universally by steam, and the power is transmitted to the several floors by ropes from the engine to the main shafts. The plant is designed to spin cotton of a certain length of staple to a particular range of counts, and the quantity of machinery in each department is exactly proportionate to that in every other. Consequently there is very little idle machinery. The load upon the engine is a constant one from starting-time to stopping-time, and this fact in part explains the preference for steam over electricity for the driving of spinning-mills. Coal is relatively cheap in the districts in which cotton is spun, and there is little waste of the power generated at the boilers. Great importance is attached to steadiness in driving, economy of fuel, and freedom from breakdown; and the building of high-speed mill-engines is a special department of textile engineering. Ordinarily the engine is housed in an annexe to the main building, situated near one of the corners of the mill. The engine and the heavy machines used in preparing cotton for the spinning-mules occupy the ground floor, and the lighter machines are placed on the upper floors of the building.

Preliminary Treatment of Cotton. Raw cotton received from the docks is taken into the bale-room, either on the ground or the first floor. It arrives from America in bales pressed to a density of 24 to 30 lb. per cubic foot, and before anything else can be done it has to be opened out into a loose condition. This is the work of the bale-breaker machine, the first of the series of machines in the *blowing-room.* The cotton was formerly loosened by the use of spiked rollers, which served the purpose, but tended to snap some of the fibres. The machine principally employed, called the *hopper bale-breaker,* has a gentler action, and helps to clean the cotton as well as to open up the matted mass. The hopper is a sort of box, of which the floor is a travelling lattice apron moving horizontally. The cotton is borne forward on this lattice, and pressed against an ascending lattice furnished with strong teeth. These comb out the fibre, and carry it upward, and at the top of the incline the cotton is met by the spikes of a roller revolving in the contrary direction. These spikes further comb out the cotton, and throw any unopened pieces back into the hopper. After passing the spiked roller the opened cotton is stripped from the inclined lattice by a beater, and falls upon a grid. From the grid the cotton is conveyed either to mixing-bins, in which different cottons are mixed together, or to a *hopper feeder.*

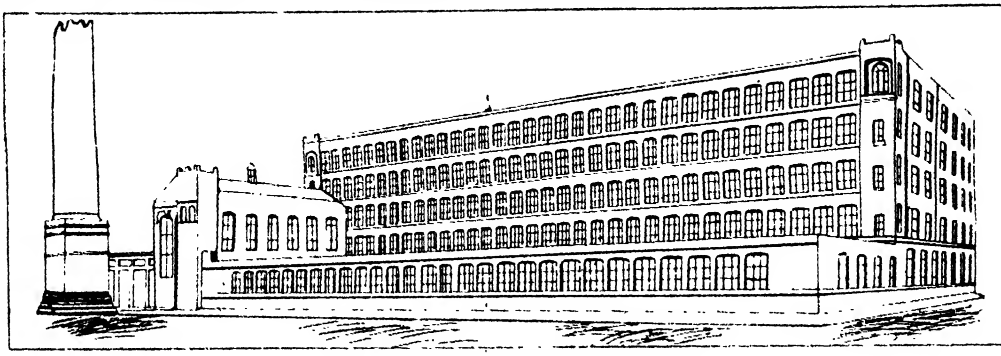
Cleaning Processes. In the feeder the cotton is similarly carried first onward and then upward by lattices and the comb-like teeth. There is a small auxiliary lattice to equalise the layer of cotton delivered from the machine, and in transit the material is beaten and loses some more of its impurities. After passing through the hopper feeder the cotton receives a further cleansing in the *lattice feeder,* in which it is conveyed to rollers which pull the fibre and present it to a swiftly rotating cylinder.

The quantity of cotton passing at one time is regulated at will, and it leaves the rollers, to be beaten severely against a grid, through which much of the sand, leaf, seed, and other impurity falls to the ground. By the action of large fans the cotton is then sucked along a tube, or *dust trunk,* passing over a ribbed lattice, which travels in the contrary direction to itself on the way, and thus a further proportion of refuse is lost.

The amount of cleaning required varies with the original state of the cotton; and where dirty grades, like East Indian, are used, it is necessary to interpose extra machines, such as the *Crighton opener.* In the Crighton machine the essential parts are a powerful fan, a cage, and an upright shaft fitted with horizontal beaters. The action of the fan induces a partial vacuum in the cage, into which the cotton is drawn at the foot. Under continued suction the cotton rises in the cage, and is beaten successively by each row of blades until it escapes at the top, to pass on to a revolving cage, and thence to a lattice.

The succeeding machine is the *exhaust opener,* and it is fed from the delivery lattice of either of the machines last described. The cotton is caught up from the lattice by an air-current, and again beaten by the arms of a cylinder against the bars of a grid. It passes over wire-gauze cylinders from which the air is being

continually exhausted by the action of fans, and this suction draws out the remaining fine dust. After going through rollers, another beating and another suction-cleaning stage are undergone. At the delivery end of the machine the cotton passes through pressure rollers, and is finally wound off in a *lap*, or fleece.



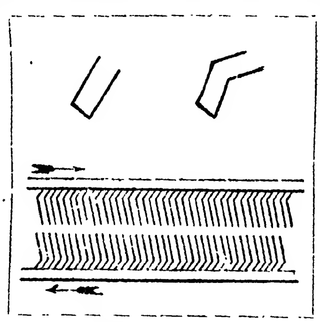
1. DESIGN FOR A MODERN COTTON MILL

The production of this lap is the goal of the blowing department, and, when made, four laps from the exhaust opener are unrolled together and passed into the *scutcher*. In this machine the four are amalgamated into one, and after a final beating and suction the lap is ready for the *carding* department. The objective is the production of a perfectly even lap, having the same weight per yard throughout its length. In working the machines there are many points to observe. The speeds of the beating rollers have to be adjusted to suit the particular class of cotton. The grid bars require careful setting, and the regulators for controlling the machine require to be kept in good order. Although the series of operations looks a long one, the provision of lattices from machine to machine dispenses with handling the cotton and the whole operations require little labour, and occupy little room.

The Carding Engine. The purpose of the blowing-room is the production of a lap, and that of the card-room is the production of a sliver. While every operation depends on, and is controlled by, the operations that have gone before, that of carding cotton is especially critical, and it is impossible to produce good yarn unless the carding is well done. Despite the series of cleaning processes, the cotton is not absolutely free from foreign matter on entering the carding-engine, so one part of the work of this machine is to remove the remaining bits of seed and leaf.

It has also to remove *neps*, which are twisted curls or lumps of fibre, and to take out that proportion of fibre which is much shorter than the average. In the lap delivered from the scutcher the fibres run at all angles, and the carding-engine has to tease out these fibres into approximately parallel order. The work is much more delicate and exacting than the formation of a lap, and a mill may need 200 carding engines to cope with the laps made by five scutchers [3].

The principal element of the carding-engine [5] is the main carding-cylinder, of some 50 in. in diameter, clothed with wire teeth [2]. The teeth are inserted in a fabric or *fillet* of cloth or rubber, and are made of finely tempered wire. The teeth are bent at a uniform angle, and are sharpened by grinding to points of specified shape. Wires of different gauges are used, and fillets are made for different purposes, with numbers of points per square inch varying from 300 to 650. The fillet is secured spirally upon the cylinder so as to cover its circumference uniformly and completely. Over the main cylinder is a lattice of cast-iron ribs, alsofurnished with card clothing, and forming an endless revolving apron. The ends of these *flats* are supported upon flexible, semi-circular rings resting upon fixed bends, which form part of the framework of the machine. The cylinder revolves quickly and the flats much more slowly. The distance between the teeth of the cylinder and the flats is capable of adjustments which are reckoned in thousandths of an inch, and between them these two sets of wires perform the critical carding operation.



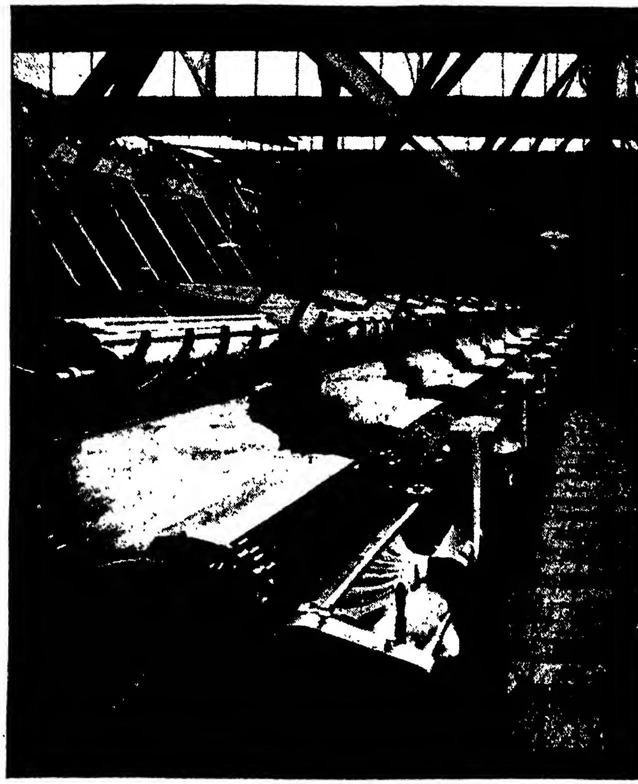
2. CARD TEETH

Carding Operations. The lap from the scutcher is lifted on to a bracket in front of the machine, where it is unrolled. The end of the lap is gripped by a fluted feed-roller, and is delivered to a taker-in roller. The cotton passes over knives and grids designed to clear away foreign matter, and is swept on to the teeth of the main cylinder. The flats move in the same direction as the cylinder, and forty of them are always in contact. As their speed is slower than that of the cylinder, the fibre is combed out straight by their dragging action, and is carried forward to the *doffer*, a smaller cylinder, also wire-covered, and rotating at a lower rate of speed. The doffer completes the straightening of the fibre, and strips it away from the carding-cylinder. The doffer is in turn stripped by an oscillating comb, and a fleece of the full width

of the machine is brought away. The fleece, which is an exceedingly fine film, is forthwith condensed by guides until finally, in the form of a ribbon, or sliver, half an inch in diameter, it passes down a trumpet-shaped orifice, and is coiled in a cylindrical can.

The teeth of the flats are continuously cleared by a comb as they leave the main cylinder, and a grinding roller sharpens and levels the teeth of the flats continuously while carding is going on. Periodically during the day the *strips*, or short fibres, and the dust lodging between the teeth require removal, and every two or three months the cylinder and doffer have to be dismounted and re-ground. Several new forms of apparatus have been brought into the mill to avoid the creation of dust during the card-stripping and grinding operations. Home Office requirements grow in stringency, and require this dust to be dislodged without passing into the air of the room. There is a choice of appliances worked by fans and by vacuum pumps, and of smaller apparatus which confine the dust inside a cover.

The lap made in the scutching-room is of such a weight as to produce approximately the thickness of sliver required from the cards, but the desired perfection of uniformity is not arrived at in one operation. The *drawing-frame* [6] is relied on to smooth out inequalities and make a satisfactory sliver; and in making all but the finer qualities of yarn the material passes from the card to the drawing-machine. In spinning the finer numbers, however, it is necessary to eliminate the shorter fibres by a more drastic process than carding. The material is passed through *combing-machines*, preparatory to which the coiled sliver from the cards is put through *lap-machines*. The systems in vogue vary in some details, but agree in bringing from sixteen to twenty carded slivers together, passing them through drawing-rollers which pull out the sliver in lengths, and combine the whole in a lap of $7\frac{1}{2}$ to $10\frac{1}{2}$ inches wide, for the combing-machine.



3. A CARDING-ROOM AT HORROCKSES

Combing Machines. The combs in use are based on a principle which occurred to the inventor—Heilmann—as he watched his daughter nipping portions of her hair with one hand and combing the hair with the other. The prepared laps are supported on two corrugated rollers, and the slow rotation of these causes the ribbon of fibre to unwind.

The cotton first travels over a highly polished plate, which offers no friction, and then passes between feed-rollers, when it is fed intermittently and in lengths of about one-quarter of an inch at a time between nipping jaws. The jaws hold the ends of the fibres during the time in which rows of fine needles, set upon a small cylinder, push their way through the material. The rows are of graded fineness, the coarse needles entering first and the fine ones last, their work being to remove fibres so short that the ends are not held by the nippers. The combing-roller is furnished with needles over one part of its circumference only, the rest having a fluted surface; and as this fluting comes beneath the nipped cotton a small detaching roller — covered with leather — is lowered. This movable roller carries the combed cotton between two fixed rollers; and as they receive the addition they roll backwards and join the cotton previously combed to the material which has newly come forward.

Thus the machine is continually treating the fibres tuft by tuft, and adding the tufts together into a continuous length by overlapping them. While the newly combed is being added to that which has gone before, the nippers open and allow a new length to come forward. The half tuft behind the nipping jaws is combed by being drawn through the teeth of similar needles by the action of the detaching roller.

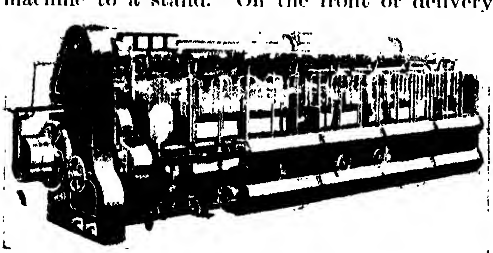
The short fibres removed from the lap are carried by the needles, from which they are removed by a brush, and the brush works in contact with a wire-covered doffer-roller, which

in turn is cleared by a doffer-comb. The waste is thus conducted to the back of the machine, and the combed sliver comes away in a web at the front. The ends of the sliver are led down to a bell-shaped orifice by rollers, and after passing through three pairs of drawing-rollers they are coiled inside cans.

The Heilmann comb is usually made to take eight or ten *heads* of slivers, and its parts are capable of the most beautiful adjustment. The Whitin comb is a modification of the Heilmann, and the Nasmith comb is regarded as the greatest improvement on the Heilmann machine that has been made. The Nasmith machine differs from the original in detail; and is capable of use upon fibre of a greater average length. Combed yarn is stronger than that which is only carded, and it is more lustrous. Yarns numbered 80s and upward are practically always combed, and it is necessary to choose combed yarn to get the best results in cotton that is to be mercerised.

The Work of the Drawing Frame. In returning to the *drawing-frame* [6] as the next in sequence in making carded yarn, it must be pointed out that its purpose is an equalising one. Its functions are to straighten the position of fibres one to another, mix the slivers from the different carding-engines thoroughly, and produce a sliver equal in all parts.

Coiled sliver is brought to the machine in cans, six or eight of which are placed together, and the contents of each are led into the machine. They pass through four or more pairs of top and bottom rollers geared at different speeds, the last rollers running faster than the first; and they thereby draft or draw the sliver finer and combine the whole into one. Varying with the counts to be spun, the material passes through the drawing-frame two, three, or four times over to secure a perfect amalgamation of the fibres. In order to avoid such trouble as would be caused by the unnoticed breakage of a sliver, the machine is fitted with stop-motions. In entering the frame each sliver passes over one of a series of *tumblers*; and the instant the drag upon this detector stops, the tumbler overbalances, and, by engaging with a rocking shaft, brings the machine to a stand. On the front or delivery



4. SLUBBING-FRAME

end another stop-motion comes into play, should the delivery cease or become too light in weight.

Twisting the Sliver. The sliver issuing from the drawing-frame is too coarse to be placed immediately upon the spinning-machine, and has to undergo a further course of stretching. As it is impossible to stretch a twistless rope far without pulling it in two, some twist has to be given to the sliver in order to allow further elongation to take place. Combined drawing and twisting is performed upon a further series of machines, and the finer the yarn that is being made the more machines have to be employed.

5. REVOLVING FLAT CARDING ENGINE

The pictures on this page are by courtesy of Messrs. Platt Bros. and Company.

Two machines serve for coarse yarns—the *slubbing-frame* [4] and the *roving-frame*. For yarns of medium fineness, slubbing, *intermediate*, and roving frames are needed. For the finest counts four frames are necessary—slubbing, intermediate, roving, and *fine roving*. Except that each successive machine has to deal with finer sliver than its predecessor, the machines are the same. They are *flyer* spinning-frames, adapted for heavy material and for imparting light twist.

The sliver comes to the slubbing-frame coiled in the can, and it is led over a guide through three pairs of drafting rollers. Leaving them, the sliver passes down the arm and through the eye of a flyer, and is twisted by the rotation of the flyer-spindle, and wound upon large bobbins, or tubes. The bobbins of slubbing are removed to the creel of the intermediate frame to be drawn and twisted a little more, and the bobbins from this frame are then lifted on to the roving-frame. On the roving-frame the procedure is the same, with the exception that usually two ends of the intermediate rove are drawn and twisted into one of roving. The fine roving-frame is requisitioned only for Egyptian and Sea Island cotton. Although the principle of each of these flyer-frames is alike, the sizes of the bobbins and flyers are not the same, and the speeds are very different. The slubbing-frame runs slowest and the roving-frame fastest.

Systems Employed in Cotton Spinning. The operations between the drawing and the roving frames are strictly in the nature of spinning, but the name of spinning-frame is reserved for the machine upon which single yarn of the desired fineness is produced. Two systems of spinning are used for cotton, both of which have been described broadly in the last chapter. They are, we may recall:

Ring-spinning, used chiefly for warp yarns in England, a form of spinning that requires little skilled labour, and can be carried on by girls.

Mule-spinning, which employs male labour, and can be used to produce yarns of every quality, and to employ any kind of cotton.

In the case of ring-frames it is impossible as yet to spin upon the bare spindle, although

inventors have made attempts to effect this improvement. The types of spindle in use vary in design, and differ principally in respect of the facilities for lubrication, a matter of importance in view of the high speeds at and long hours for which the machines run.

Type of Cotton	Production in Hanks per Spindle in 10 Hours upon	
	Ring-frames	Mules
16s American	9 860	6 26
40s American	7 528	5 26
60s Egyptian	6 346	3 98
80s Egyptian	5 260	3 37

By comparison with mules the machines have few parts, and the production per spindle within a given time is materially larger. A comparison of the production in ten hours, taken from Messrs. Platt's tables, shows the differences given in the table on this page.

(= 336,000 yards per pound) can be spun almost without breakages. The mules for fine yarns are fitted with a *jacking* motion, which can be brought into play to secure an extra stretching, if desired, over and above that given by the ordinary outward run of the carriage. By use of this motion the drafting-rollers are stopped prematurely while the spindles are still working. Again, the fine mules are given a *double-speed* motion to accelerate the twisting in the case of very fine yarn.

The production from the mule machine is governed by the number of *draws*, or outward runs per minute of the carriage, and by the length of the *stretch*, which is shorter for fine yarns than for coarse ones. A mule spinning thick counts of 6s to 12s makes on the average over five and under six draws per minute. In spinning 60s to 80s yarn, the carriage runs out about three times a minute; in spinning 300s, the mule makes one stretch of 48 inches per minute.

6. SLIVERS PASSING THROUGH A DRAWING-FRAME

The amount of twist imparted, which is a controlling factor in the output of any kind of spinning-frame, is, it may be noted, approximately equal in each case.

Spinning-mules are known as Oldham or as Bolton mules, according to whether they are designed to spin the classes of cotton and counts of yarn generally produced in these towns. The *fine spinning* or Bolton mule is fitted with refinements not needed upon those for spinning medium counts, and so delicate is the arrangement of the finest mules that cotton up to 400s

A Triumph of Cotton Spinning. It will be seen that production at the rate of 48 inches per spindle per minute, the making of one pound of yarn 252,000 yards long is a slow process. The value of the product is, however, high, and worth commercially about 26s. per pound, or as much as thrown silk. The highest triumph of the cotton-spinning art, number 400s, measures about 190 miles to the pound, and is worth 90s. a pound, or about three times as much as the finest silk.

J. A. HUNTER

An Introduction to the Study of the Earth's Crust. How the Solid Crust was Formed.

THE MAKING OF THE EARTH

Geology, as its Greek name indicates, is "the science of the earth." It deals with the *structure* and the *history* of the planet on which we live, and with the *natural processes* which have moulded it. It endeavours to show how the world around us may have developed out of the gaseous *nebula*, or fiery haze of clashing atoms, which represents the earliest form in which the materials of the earth can be pictured by the scientific imagination. It teaches us to read the wonderful record which is written in the folds of the rocks and stamped upon the surface of the earth, and so to form an idea of the various stages through which our planet must have passed before it could be the fitting abode of human civilisation. Finally, it enables us to look with the eye of science below the smiling surface of fields and parks, or the sandy desolation of the desert, and to predict the places in which the miner, the railway engineer, and the well-sinker may begin their operations.

Geology an Open Air Study. The study of geology presupposes some knowledge of *geography*, or the superficial features of the earth, which it is the function of the geologist to explain and interpret. As a preliminary to his study, the student should read the chapter on the Solid Earth, beginning on page 287. It is further necessary to assume an elementary acquaintance with *chemistry* and *physics* when the student begins to inquire into the mineral constituents of the *earth's crust*. The student will obtain these from the special courses on the subjects.

The science of geology must be studied in the field and the quarry, no less than in the lecture-room and the museum, if it is really to tell a vital story. Indeed, the special charm of this science is that the best place to study it is in the open air, and that the most essential piece of apparatus for the scholar is a good pair of eyes and a strong pair of legs. The main *laws* of geology can be studied within the range of a holiday walk, though it may be necessary to travel far afield in order to witness their application on a larger scale. Here it is possible only to give an outline of the chief facts which are known with certainty about the materials of which the earth's crust is made, and the natural processes which have built them up into the fair and fertile earth on which we live. We endeavour, therefore, in this course of study, to set them forth much as an intelligent lad might be able to deduce them from a series of rambles with a practical geologist, saying as little as may be about those branches of the science which can be properly learnt only in a well-equipped laboratory and under the direct supervision of a teacher.

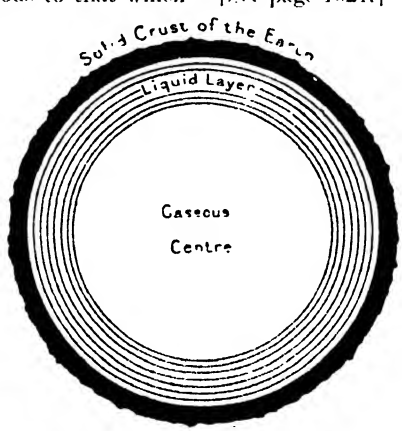
Subdivisions of Geology. The first thing which strikes the would-be geologist with open eyes, in the course of such a country ramble, is that the *features* of the earth's surface always differ, and yet are always recurring. Every turn in the road introduces a slightly different *landscape*, which, nevertheless, depends for its formation on a comparatively small number of details variously combined. The study of these details, with their unison in the several types of scenery, is the subject-matter of *Descriptive Geology;* the study of the natural processes which modify them is the subject-matter of *Physical Geology*, and the study of the changes through which they have come to exist in their present form is the subject-matter of *Historical Geology*. All the numerous subdivisions which learned inventors of names have suggested come under one or other of these main classes. We can, in short, study only the present and the past—what is and how it has come to be.

Geology deals chiefly with the *crust* of the earth, because it is the most important part of our planet - the part on which we live. It is also the only part which we really know. Man has done little more than scratch the surface; his deepest borings go down little more than a mile—one four-thousandth part of the distance to the centre. We can, indeed, infer a good deal as to what lies lower down, but we soon come to the intensely heated *interior*, as to the physical condition of which geologists are not yet quite agreed. It is almost solely the crust that we shall study, and chiefly that part of it which lies within a few feet of the surface. First, however, we must take a glance at the history of the earth as a whole. This belongs as much to *astronomy* (the course on which may be consulted for further details) as to geology, but some acquaintance with it is an essential preliminary.

The Earth as a Blaze of Light. The earth was once "a fluid haze of light." The whole *solar system*, in which it is one of the smaller *planets*, was originally a vast *nebula*, or swarm of fiery dust and gas molecules, roughly spherical, and more than 5000 million miles in diameter. This nebula was all rotating about its centre; it was also cooling, by the radiation of heat into space, and contracting. As it contracted it shed a series of rings at varying distances from the centre, each of which, with one exception, gradually coalesced into a planet revolving round the central portion, which formed the comparatively small star which we call the sun. The four outer rings gave birth to the major planets—Neptune, Uranus, Saturn, and Jupiter—which are still in a more or less nebulous condition. The next ring never coalesced, but broke up into a large number of

asteroids or minor planets. There were still four rings left behind as the nebula contracted, which formed the four inner and smaller planets—Mars, the Earth, Venus, and Mercury.

Our First Glimpse of Earth. Thus our first distinct glimpse of the earth shows it as a *nebulous star*, still intensely hot, and with no solid nucleus, rotating on its own axis, and at the same time revolving round the sun in a nearly circular orbit. The brilliant researches of the late Sir G. H. Darwin have illuminated this dawn of terrestrial history in a most curious and interesting fashion. The earth at present revolves on its axis in 24 hours—the artificial measure of time into which we divide the natural unit of the day fixed by the earth's rotational period. But it is steadily losing time. The tides, which are diurnally caused by the joint attraction of the sun and moon, sweeping round the earth in the direction opposite to that of its rotation, form a friction-brake precisely analogous to that which is used on the wheels of railway carriages or motor-cars. The retardation thus caused is so small as to be imperceptible in an ordinary lifetime; it amounts only to a lengthening of the day by about one-hundredth of a second in a century. But in the vast periods of geological time even a tiny change like this accumulates to a serious quantity. And when the earth was still plastic, or even liquid—as it must have been in the process of cooling down from its nebulous state—the tides produced by the sun and moon in its actual substance must have operated as a far more powerful brake. [See pages 424 and 1023.]



A SECTION THROUGH THE EARTH ACCORDING TO THE THEORY OF PROF. ARRHENIUS

Calculating this secular retardation backwards, Sir George Darwin showed that there must have been a time when the day was only two or three hours in length. The effect of tidal friction also operates on the *moon*, since, by Newton's Second Law of Motion, action and reaction are equal and opposite. The moon is constantly travelling away from the earth, and at the same time revolving more slowly. Working this problem also backwards, Sir George Darwin was able to show that there must have been a time when the earth was rotating in a period of between two and three hours, and the moon was revolving round it at the same period, at a distance almost inappreciable.

The Origin of the Moon. Another step in this luminous research was to show that when the earth was a liquid spheroid, rotating rapidly about its axis, it must have been in a state of dangerously *unstable equilibrium*. We do not know the exact speed with which it began to rotate after the nebular ring had coalesced, but we do know that at first, under the influence of solar gravitation, that speed must have tended to increase. Thus the liquid globe of the earth was exposed to two contending forces—that of gravity, which held it together, and that of the so-called centrifugal force, which tended to make it break up, as a grindstone or a fly-wheel bursts when spun too fast. It can be shown that when the period of the earth's rotation had decreased to about two hours and twenty minutes, these two forces were exactly balanced. The least increase in speed would overcome the force of gravity, which, of course, remained constant, and something must give way.

"The Moon Flung off from the Earth." It cannot be a mere coincidence that the calculation of the moon's motion, when it was all but in contact with the earth, shows that it must have made a complete revolution in something between two and two and a half hours. The conclusion is irresistible. Originally the moon formed an integral portion of the earth. [See page 1021.] But as the speed of the earth's rotation increased under the gravitational pull of the sun, it crept up to the critical velocity at which the earth could no longer hold together. There was a vast cataclysm, beyond anything which we can imagine, and the moon was flung off from the spinning earth—possibly in the form at first of a meteoric ring, which eventually condensed into our satellite. As soon as the moon had an independent existence, it set up vast tides in its parent earth, which acted as a powerful brake. The earth's rotation began to slow down again, and the moon began to travel outward in a widening spiral. This beautiful theory of the moon's evolution is now generally accepted. Thus we can read the history of the first, and still the greatest, geological cataclysm of which there remains any record.

The Earth and its Envelopes. The earth, as we know it, is an *oblate spheroid* [see page 6]. The cause of this departure from the perfectly spherical form—which would have been assumed by the earth if its materials had coalesced under the sole influence of gravity and cohesion—is the earth's rotation combined with the solar tide. Calculation shows that the present shape of the earth is that which would have been assumed by a liquid globe rotating at its present speed, whence we conclude that the earth solidified at a time when its rotational period was practically the same as it is today.

The earth consists of shells, like an onion. It is a globe covered by a solid crust—the *lithosphere*—which is surrounded by an envelope of air—the *atmosphere*—and in part by an envelope of water—the *hydrosphere*. It is the lithosphere, and especially the crust by which it is bounded, with which geology is mainly concerned. The outer envelopes are chiefly

A DISTANT VIEW OF MATAVANU, A VOLCANO IN THE PACIFIC ISLAND OF SAVAII

SWEEPING DOWN TO MEET CALM OCEAN

STEAMING LAVA RUSHING INTO THE SEA FROM THE VOLCANO OF MATAVANU

INSIDE THE SMOKING CRATER OF VESUVIUS

THE SMOKING CRATER OF VULCANO

SMOKE AND FIRE POURING FROM THE VOLCANO OF MATAVANU

of interest from the effect which they have on the surface of the crust.

Atmosphere and Water. The atmosphere, or outer envelope of the earth, consists chiefly of the air we breathe, a mechanical mixture of the gases, oxygen and nitrogen, in the proportions by volume of about 1 to 4—exactly 20·6 O to 79·4 N—with a small, varying amount of carbon dioxide and water vapour, and traces of rare gases like argon and helium. It extends perceptibly to a height of about 200 miles [see page 149], though more than half of it is compressed by gravity to within three miles of the surface. It is equal in weight to an envelope of water covering the whole earth to a depth of 34 ft., and exerts a pressure on all substances at sea-level of rather less than 15 lb. to the square inch (one atmosphere). Its geological effects are very considerable, as the rocks of the lithosphere are superficially modified by wind—laden with dust—rain, hail, and snow.

The *hydrosphere*, or surface water of the earth, also plays a great part in the work of geological change. This water is sufficient, if the surface were a dead level, to cover the whole earth to a depth of nearly two miles. But the various forces which have been at work in the course of the last hundred million years or so have modified the earth's surface so that it presents considerable inequalities of level [see pages 8 and 287]. Consequently, the water of the hydrosphere has chiefly collected itself into the seas which occupy the depressed portions of the surface, and which cover nearly three-fourths of the whole area of the earth — about 145,000,000 square miles. A considerable part of the water is always suspended as *vapour* in the atmosphere, and a complete system of circulation is set up under the solar influence. [See the course on GEOGRAPHY.] The water evaporates from the seas, falls as rain on the land, and is returned to the sea by the rivers which it thus forms. It is one of the most effective agents in the geological operations which are constantly altering the surface of the earth.

The Solid Earth. The great bulk of the earth consists of the *lithosphere*, or solid globe of rocks, with which geology properly deals. It is on the part of this lithosphere, composing a little more than a quarter of the earth's whole area—55,500,000 square miles—[see page 556] which rises above the seas and is called land, that mankind lives. Practically the whole of its surface is exposed to the study of the geologist, who is also acquainted with its interior structure, as displayed by mines and bore-holes, to the depth of something over a mile. It is his business to form inferences as to the condition of the parts which he cannot directly explore. He has also to tell us why the land is diversified so much, by plain and table-land, mountain-range and valley-system; why the rivers flow through it, and what dominant force has traced their courses; why one kind of soil is better suited than another to the purposes of agriculture; and how the miner can best prospect for the shafts with which he hopes to tap the mineral resources of the earth's interior. Only a long and thorough course of study can enable him to do all this, but the principles on which he depends are outlined in the following chapters.

Astronomy has already taught us that the earth was once so hot as to be a mere nebula, composed either of fiery gases or of glowing particles of matter such as we now call meteorites. We know, by common experience, that its surface is now cool and hard, and mostly composed of solid rocks, with a mantle of soil varying from one or two to hundreds of feet in thickness. How has this great change been brought about?

THE SPIRAL NEBULA IN CANES VENATICI, WHICH MAY INDICATE THE MANNER IN WHICH OUR EARTH WAS FORMED AGES AGO

Influence of the Earth's Motion. We know that three different agencies have been at work on the original nebula. It was originally in motion, rotating around its own axis, and this motion has been preserved and handed on to the earth. It was intensely hot, and has been losing heat ever since. And it was made up of some sixty or seventy different substances—the so-called elements of the chemist—which have since entered into numerous kinds of combination with one another.

The nebulous earth has constantly been losing *heat* by radiation out into space. All bodies, with some negligible exceptions, contract as they cool. Thus the nebulous earth steadily contracted as it lost heat, until finally it began to change from glowing gas into a very hot liquid—a globe of molten rock—from which, as we have seen, the moon was shot off under the influence of the centrifugal force.

The exact steps of this *liquefying process* are still in doubt. We can never hope to trace this far-off part of the earth's history with any great accuracy; it is so much a question of inference and hypothesis. Some hold that the liquefying process began at the centre of the nebulous mass, for, though the heat may have been greatest there, so was the pressure, amounting perhaps to 3,000,000 atmospheres, or 20,000 tons

to the square inch; and we know that the melting-point of nearly all substances rises in proportion to the pressure exerted on them. Others assert that it began at the outside, where cooling was fastest. What is certain is that it did begin somewhere, and continued until the whole vast nebulous bulk had shrunk into what we may for brevity call a liquid or plastic globe some 8000 miles in diameter.

The Solid Crust. Meanwhile, *chemical changes* have been going forward. At the high temperature of the original nebula it is probable that all the elements existed by themselves, being too hot to enter into combination. [See CHEMISTRY.] But as they cooled they began to form compounds; the iron and the oxygen rushed together, producing some oxide of iron; hydrogen and oxygen gave birth to water-vapour; silicon and oxygen produced quartz, and so on. Here the history of the earth belongs rather to chemistry than to geology.

The geological story really begins with the formation of the *solid crust* on the surface of this liquid globe. As the secular cooling went on, the outer parts of the liquid mass must have begun to harden and solidify, just as the lava from a volcano or the slag from a blast-furnace hardens when exposed to air. At first, no doubt, the hardened portions sank into the fiery liquid, and were dissolved again, but in time they began to become thicker and larger, and to adhere together, uutil at last the whole globe was covered with a skin of solid, though still intensely heated, rock. The atmosphere meanwhile shrouded this globe, and began to check the rate at which heat was lost; it contained not only the air which we breathe today, but all the water of the oceans and rivers in the shape of superheated steam, as well as vast quantities of carbon dioxide, much of which is now fixed in our coal-measures.

Heat of the Earth Within. An important evidence of the formation of this solid crust is to be found in the well-known fact that the earth is still *hotter within* than it is on the surface. The phenomena of volcanoes, geysers, and hot springs bear witness to the existence of some internal reservoir of heat. That this is not merely local, but universally distributed, is shown by the fact that wherever we bore into the earth's crust we find the temperature steadily increasing as we go down. On the average, the increase is 1° C. for every 90 ft. of descent. The actual rate varies widely according to the local conditions, but that is about the mean of numerous observations. If this rate were kept up, the temperature at the centre of the earth would be over 200,000° C. Probably the rate of increase does not remain so great; it must be remembered that we can follow it for only six or seven thousand feet. But there is no doubt that the interior of the earth is exceedingly hot. At a depth of 100 miles the temperature would be 5700° C. above that of the surface, and no known substance would in the ordinary course remain solid. Thus the earlier view of the earth held it to consist of a solid crust, 50 to 100 miles thick, floating on a molten globe, serving as the common reservoir for volcanoes.

Condition of Earth's Interior. But this view has been seriously modified by the progress of knowledge. Astronomers have shown that, if the earth's interior were really fluid, the sun and moon would cause vast tides in it which would seriously perturb the motion of our satellite. Nothing of the kind takes place, and it has been calculated with entire certainty that the earth, as a whole, must be far more rigid than if it were a globe of solid steel. The earlier geologists omitted to take account of the immense pressures which the weight of the superincumbent strata exerts upon the materials of the earth's interior, and which greatly raise the melting-point of the ordinary rocks. Thus, the modern view is that the interior of the earth is practically solid all through, in spite of the immense temperature which must prevail in it. The best theory is that of Professor Arrhenius, who has put forward the view that the earth is a vast bubble, consisting of a solid crust perhaps 30 or 40 miles thick, resting on a liquid magma of 60 to 100 miles, which shades off into a globe of gas.

But this gas is very different in physical properties from any which we know in our laboratories. That it is gas we argue, because the temperature at this depth must be higher than the critical temperature of any known substance—that is, the temperature at which a substance can remain solid or liquid under any pressure. [See PHYSICS.] But it is gas under a pressure so vast that its density is two or three times greater than that of any known rock, and its rigidity and incompressibility are greater than those of steel. Probably at least half of this gas consists of iron and other metals.

The Earth as it is. The earth, then, which geology has to study, consists of *a series of shells of matter* in different states. The *central core* is a globe of about 7600 miles in diameter, which is composed of iron and other elements, probably not forming compounds, in the gaseous state, but exposed to such tremendous pressure that it behaves as a solid and extremely rigid body. Outside this core is a *shell of liquid matter* which consists of all the rocks which we know at the surface in a state of fusion, perhaps 100 miles in thickness. Upon this magma floats the *solid crust*, 30 or 40 miles thick, which is composed of the various rocks which we have now to study, breaking down at the surface into soil. Three-fourths of the surface of this crust are covered by the *water of the oceans*, the hydrosphere, the rest being dry land. Outside all comes the *atmospheric mantle*, chiefly composed of air, which supports life, acts as a blanket to keep the earth warm, and as a shield against the blows of meteorites.

Before we can proceed to consider the later history of the earth, and to ask how the hot, bare rocks have given birth to the habitable earth on which we live, we must study the more important materials of which they are composed.

W. E. GARRETT FISHER

The Hydraulic Cylinder and Ram; Hydraulic Jacks of Various Types. The Punching Bear and Wheel Press; Hydraulic Lifts and Cranes.

APPLICATIONS OF HYDROSTATICS

Hydraulic Rams. Pursuing the applications of hydrostatics into varied mechanisms, we find that the most important is the hydraulic cylinder and ram. In this appliance a solid ram or plunger fits within a cylinder into which water under pressure is admitted, thereby causing movement. The cylinder, or else the ram, is set in motion thereby. Generally it is the ram that moves, as in the hydraulic platform or station lift, and in baling presses, or flanging presses, types of a hundred other machines. But sometimes the cylinder is made free to move over the fixed ram, the alternatives being matters for convenience. Obviously, too, the positions of the mechanism are of no importance. Though in most cases set with the axis vertically, they are often horizontally, and in some cases inclined. Also the lift may be direct, the table platform, or platen, being attached to the head of the ram. Or chains may be brought round pulleys at the head of the ram, and, with suitable anchorages, used to impart motions that are not in a direct line with the movements of the ram. These occur in jigger hoists, and in many kinds of hydraulic cranes. Pressure is also often transmitted by jointed or walking pipes instead of rigid ones, to avoid having to reconnect, as in hydraulic riveting plants.

It should now be readily seen that, given the foregoing elements, capable of producing strong pressure and transmitting it by a liquid which is practically incompressible, enormous possibilities in application are opened up. The following are a few examples which are selected from a much wider practice, and each of which occurs in machines the details of which are modified in many ways in the hands of different manufacturers according to their needs.

The Hydraulic Jack. This is a simple machine for gaining enormous power, but with its accompaniment of very slow movement, resembling in this respect the differential pulley blocks. Both are invaluable when heavy loads have to be lifted by human energy alone. The jacks will lift locomotives, ships, bridges, by the operation of a hand lever, and in modified forms they will push loads slowly. They are emergency tools out of doors, where cranes are not available. Their general construction is shown in **103**, which represents a Tangye lifting-jack that combines two functions in one—that of lifting on the head A, and also on the foot B, the latter being an invaluable addition when there is little space between the object to be lifted and the ground. The construction of the jack is as follows.

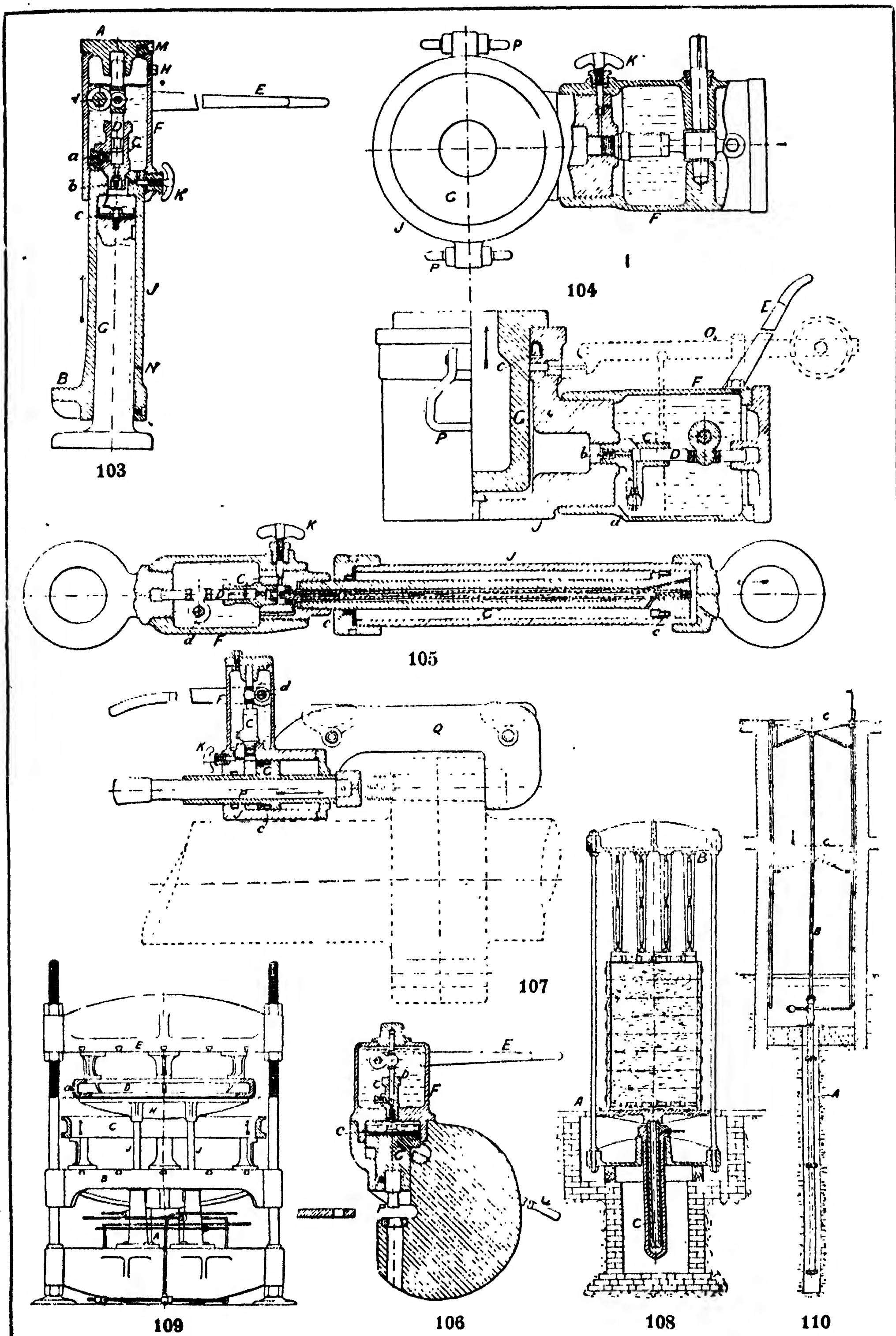
C is the body of the force-pump, and D its ram, actuated by the lever E, drawing the water from the cistern F, by the pressure on which between the ram G and the casing J the latter is forced upwards. In the force-pump CD we recognise the same type of pump that was illustrated in the previous article [page 1568]. The difference in the area of the ram D and that of the ram G of the jack represents the theoretical gain in pressure.

Operation of the Jack. When in operation, the cylinder J should first be down to the bottom of the ram, as shown by the drawing. The cistern F is then filled with liquid, either by removing the cover A or by taking out the charging screw H and filling through its hole. Clean water must be used, or rain water, or condensed steam with ¼ oz. of soda added. In cold weather glycerine is added to the water to prevent freezing—one part of glycerine to three of water. The lowering screw, or stop-valve K, is then unscrewed, and the lever E, pivoted at *d*, worked a few times, by which means water is forced through the pump into the space L, and any air present passes through the valve K into the cistern F. A little more water is added through H to take the place of the air driven out. The air-screw M is left slightly opened all the time to allow freedom of escape to the air. The cylinder J rises on the ram G until the water comes out of the blowhole N, though it is not well to lift to the extreme limit, as the leather packing (*c*) is liable to become damaged.

To lower the jack, the screw K is slackened, which leaves a free passage of the liquid from L to F. If the height to which a load has to be lifted exceeds that of a single "run-out" of the jack, then the jack is raised on blocking, and another lift taken.

There are a good many practical points about the working of these jacks, but only one can be referred to here—the care of the leather packings (*c*). Nothing yet has been substituted successfully for leather, so that the old saying "nothing like leather" is in this connection absolutely true. A peculiarity to be noted is that the leather is cupped in such a way that the harder the pressure the more tightly is the leather pressed out against the walls of the cylinder. Sometimes even a leather which will be leaking when a ram is doing no work will cease leaking as soon as a load is put on. The troubles to which leathers are liable are mainly due to their drying and shrinking. Next to these the presence of grit is most harmful. When leathers have to be cleaned they are taken out and soaked in water or oil.

With regard to lifting a load on the claw B, it is obvious that the full load which can be taken on the head A cannot be put on the claw. It is, therefore, not judicious to carry more than



103-110. HYDRAULIC PRESSURE MACHINES

25 per cent. of the jack-load on the claw if the lifting be a high one. For a short lift nearly the maximum load may be carried with safety.

Modified Jacks. Around this simple mechanism, which is but a modified form of the essential Bramah press, engineers have built many designs, a few of which we shall now notice. Some of the reference letters are retained in the subsequent figures for the purpose of ready identification of similar parts in other machines.

Given the jack itself, one of the first improvements effected with a view to increase its range is to impart a horizontal motion bodily to it—the *traversing jack*, a movement effected by a screw. An object after being lifted can thus be moved along bodily within a limited distance by this type of jack.

Ship Jacks. Jacks are utilised for lifting ships, hence termed ship jacks [**104**], though, of course, suitable also for bridges and other heavy works. Here we recognise the force-pump, but set in a horizontal direction, and operating a vertical ram. But while the jack in **103** is made for loads up to about 50 tons, the ship jack is made as high in power as 400 tons, which explains the enormous disproportion in the diameter of the rams D and G in **104**, the drawing being made to scale. Note also the great thickness of the metal in the cylinder J which encloses the ram, and receives the pressure tending to rupture it. The only other differences that need be noted are the form of the packing leather, and the safety-valve in **104**. The leather (*c*) is of the U section, that being more suitable than the cup form in **103** for withstanding enormous pressures. The weighted safety-valve lever O, though often omitted, is desirable because of the severity of the pressure, which, if much exceeded, might rupture the cylinder or the pump. The power of this small jack is thus equal to the lifting of four of the largest locomotives with their tenders.

Pulling Jacks. In these examples the power is applied to the exercise of thrust or push, but it is equally applicable to a pull. A special form, therefore, is the pulling type [**105**]. There are confined spaces where even the snug pulley-blocks cannot be used to pull a load, as in shaft tunnels, and sometimes in the engine-rooms of steamers, and then the pulling jack, operated by a pressure pump, is a boon to the men who have to execute hurried repairs.

This jack has the same cistern, force-pump, and stop-valve, but a tube (G) takes the place of the ram, and the water pumped from the cistern passes through the bore of this tube to the underside of the piston. The latter forms an enlargement at the end of the tube, and has a U leather packing (*c*). The eyes fitted at the ends are in union, one with the cistern and thence with the tube, the other with the cylinder for connecting to the work, and to any suitable point of attachment. In operation, the tube is drawn out as far as is required, and the act of pumping pulls it in, drawing the work along with it. The jack is used indifferently in a vertical or horizontal position. Machines of this kind are made with powers as high as a 25-ton pull, with a maximum run-out of 36 in.

The Punching Bear. Nor is it only in pushing and pulling that the coercion of pressure-water is in evidence. The same essential mechanism—that of the small ram of a pump and the large-power ram—are used for punching holes through steel, and for shearing the edges of steel sheets. Fig. **106** shows one of the first variety, which is made by Messrs. Tangye, of Birmingham, a most useful machine, termed the punching bear. Its utilities lie in the formation of holes in girders and other plated work in localities which do not admit of the utilisation of the fixed power operated machines. A man or two men can handle this machine, yet it is powerful enough to drive rivet-holes through iron plates $\frac{3}{4}$ or 1 in. thick.

The top lever E actuates the force-pump, and sends pressure-water into the chamber above the ram G, pushing the latter down. The punch P being fitted into a hole in the latter partakes of its movement. The function of the lower lever Q is to raise the ram and punch, previous to which the stop-valve must be opened to allow of the escape of the water back into the cistern.

Around this design many larger punching machines are built for special work. They include machines for punching tram rails, girders, channels, and copper sheets. Some are portable, being mounted on wheels for movement to work in progress, on railways, and in streets. Some have so little resemblance to others that a superficial observer would hardly see the relationship, but they all embody the same principle—that of the Bramah press. Some, too, are used for closing rivets. Also, by substituting shear blades for the punch and its bolster, we have the hydraulic shearing machines, a large group now extensively used.

The Wheel Press. This is a machine for pulling railway wheels on their axles, and taking them off by the simple exercise of water-pressure. The wheels on their axle are slung between heads, which afford the necessary resistance to the water pressure. They are capable of exercising total pressures ranging from 80 to 200 tons. Many of these are worked from an accumulator.

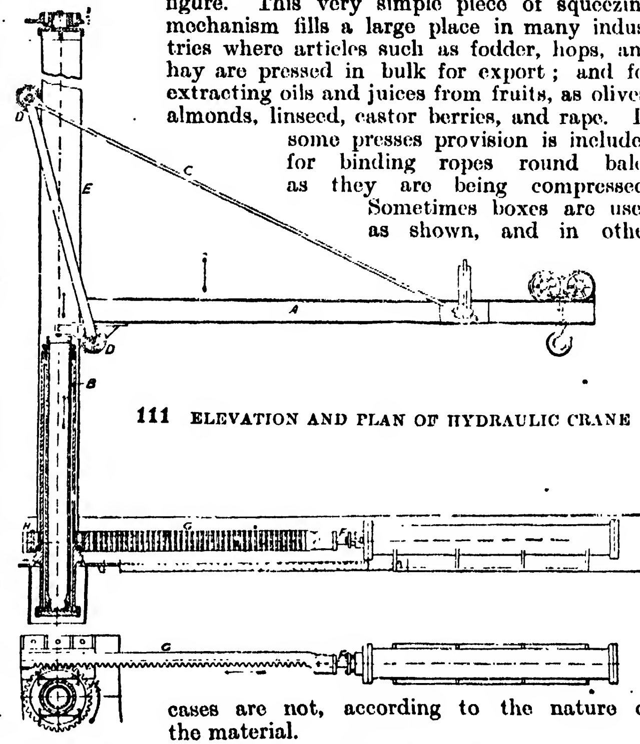
Bolt Forcer. The same principle is adopted in the bolt forcer [**107**], a small machine which pushes bolts home, and rusty ones out of their holes. They are capable of exerting pressures of from 20 to 75 tons on a refractory bolt. The ram here (G) is hollow, to receive a steel drift (P) which is forced along by the ram against the tail of the bolt to be pushed out. The resistance is taken by the arms or claws Q, two in number, so flanking the bolt on each side. A propeller shaft with a bolt about to be forced out of the flange is indicated in dotted outlines. The arms (Q) have handles for lifting and transportation. Figs. **104**, **105**, and **107** illustrate examples from the practice of Messrs. Youngs, of Birmingham.

Another machine forces the big propellers of ships off their shafts by the persuasive power of a little water judiciously applied.

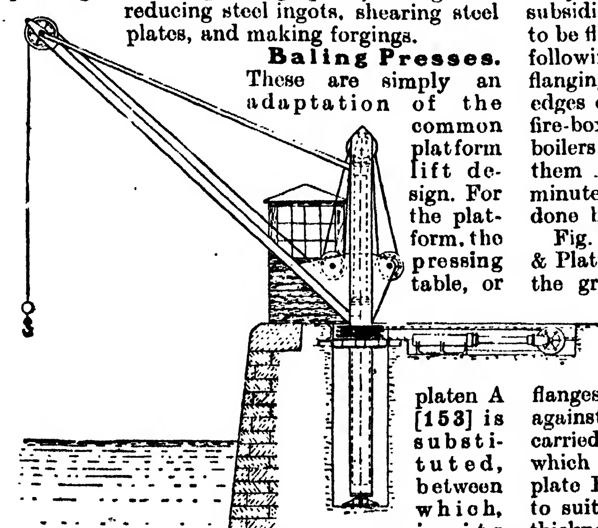
Yet another group identical in principle of operation include the bending and straightening machines. These may often be seen in the streets where tram-lines are being laid down. Pressure either to bend or straighten is applied between the end of the ram and a pair of claws, or hooks, opposed thereto, and to right and left, the rail being gripped between so that the pressure takes place at three points. Pressures of 40, 50, or 60 tons are thus obtainable.

In the shops there are larger machines used for straightening steel beams, precisely the same in essential mechanism, but differing in outline, being fixed on massive bed-plates. When steel girders, joists, bars, and other sectional forms have to be either bent or straightened, this is not done by the brutal method of hammering, but by squeezing. The machine may be described as a hydraulic jack (the ram) so mounted as to push the girder or beam in opposition to two points of resistance. Being under control, the pressure can be arrested when the beam is either straightened or bent to the curvature required.

Presses Using Accumulators. The members of this group are as numerous as those we have already considered, and they are generally much more massive in form. The most familiar are those for lifts for passengers and goods, for pressing or baling, flanging, squeezing and reducing steel ingots, shearing steel plates, and making forgings.



111 ELEVATION AND PLAN OF HYDRAULIC CRANE



112 HYDRAULIC CRANE

Baling Presses. These are simply an adaptation of the common platform lift design. For the platform, the pressing table, or platen A [153] is substituted, between which, in its upward movement and the head B of the machine, fixed above, the loose material is pressed, often with a force of from two to three tons on every square inch. Hay is pressed thus into a bulk one-sixth that of the original truss. The motive power is still the force-pump and accumulator actuating the ram C in the figure. This very simple piece of squeezing mechanism fills a large place in many industries where articles such as fodder, hops, and hay are pressed in bulk for export; and for extracting oils and juices from fruits, as olives, almonds, linseed, castor berries, and rape. In some presses provision is included for binding ropes round bales as they are being compressed. Sometimes boxes are used as shown, and in other cases are not, according to the nature of the material.

Flanging Presses. These are a special variant on the baling press and kindred types. They contain more mechanism, in the form of subsidiary side-rams, that push the boiler plate to be flanged up against one die, which is fixed, following which the main ram pushes the flanging, or movable die up, so bending over the edges of the plate against the fixed ram. The fire-box and tube-plates for locomotive and other boilers are turned round thus, instead of flanging them by hand, the process occupying a few minutes against hours required when they are done by hand hammers.

Fig. 109 illustrates a flanging press by Fielding & Platt, Ltd. The cylinder and ram are below the ground, as in the baling press, but only the top of the ram is shown in the figure, at A. This lifts the movable plate B, which carries the lower flanging die C on stools, which die flanges or turns over the edges of the plate G against the edges of the upper die D. D is carried by stools against the fixed plate E, which thus resists the pressure of the lower plate B. E is, however, adjustable in height to suit different pieces of work and different thicknesses of dies. Before the actual flanging of the plate G takes place, the plain plate is brought up and held against the upper die D by the plate H, which has a vertical movement independent of that of B through

four small hydraulic rams J. The object of this provision, distinct from the squeezing, is to permit of making precise adjustments of the plate before flanging it. Hundreds of these machines are in use, doing work with a silent squeeze better, as well as more quickly, than hand work was ever capable of doing.

Forging Presses. These form an immense group, comprising machines more or less specialised. The largest forging press in the world is the 14,000-ton press of the Bethlehem Steel Works. There are some immense presses in Sheffield for forging down ingots for armour plates. Essentially they comprise the ram and cylinder. They have entirely displaced steam hammers for the most massive work. It would be impossible to forge the big propeller shafts and the guns and armour plates by steam hammers with sound results, to say nothing of the concussion of hammers, which does not exist with presses.

In forging presses are included large groups which deal with comparatively light work, which they bend and mould in all conceivable shapes. At the Swindon G. W. R. Works and elsewhere there are numbers of these presses in a great shop in silent operation making buffers, horn blocks, and the numerous forgings required for carriages and waggons.

Lifts. In the direct-acting lift [110] the hydraulic cylinder A is sunk in the basement. By the admission of pressure-water from the accumulator, the ram B is lifted. As it carries the platform C on its upper end, the platform partakes of the lift movement, and is carried up to a distance corresponding precisely with the amount of vertical travel of the lift. The descent is accomplished by gravity, by letting out the water, the rate of which is under control. The capabilities of this simple mechanism are almost without limit. Two extremely powerful installations of this kind are the canal lifts at Les Fontinettes, and on the Canal du Centre, Belgium. In the latter a trough of water, weighing 1,100 tons, and containing a barge, is lifted to a height of 50 ft. in 2½ minutes. This load is sustained by one ram 6 ft. 6¾ in. diameter, and the pressure is 470 lb. to the square inch. On the Neuffossé Canal, at Les Fontinettes, similar lifts, but weighing 700 tons, are lifted 43 ft.

Hydraulic Cranes. As these were the first mechanisms to which water pressure was applied (by Armstrong, at Newcastle), so they are still used to an immense extent for light as well as heavy loads. Details vary widely from the plain types shown in 111, 112, to the vast coal-tips which lift a 20-ton waggon of coal, tip it, and return the waggon to the rails in a period of time as brief as a minute.

The crane shown in 111 is of the direct-acting type—that is, the jib A with its load is lifted by the upward movement of the ram B. The jib is steadied by the rods C and rollers D above and below against the post E. The rotation of the jib is accomplished by another ram (F), set horizontally, and moving a rack (G), turning a wheel (H) that encircles the post E. More often a chain is used for turning, as indicated in the skeleton drawing 112. In this example the lifting of the load is done with a fixed jib. The ram is shown at the top of its stroke, and its movement draws the rope or chain round the pulleys shown, so lengthening or shortening the lift at the hook.

Other Applications of Hydrostatic Pressure. The foregoing is a small but representative selection of the utilities of power-water. The following is a short summary only of other ways in which hydrostatic pressure is employed in engineering structures.

It is applied in many turning operations, for, as we have seen, the cylinders can be arranged in any positions, and connected by chains or racks and pinions to the parts to be moved. Hence we have it working the steering gear of the largest ships, for which hand power would be utterly incompetent. Large swing-bridges are operated similarly. There are many of these in existence for road and railway traffic. One of the latter, over the River Ouse, at Goole, weighs 670 tons, and is actuated by engines having three cylinders arranged radially, and worked by water at a pressure of 700 lb. per sq. in. One over the River Tyne weighs over 1,200 tons. The huge bascules of the Tower Bridge are raised and lowered by hydraulic engines, besides which the hoists for taking foot passengers up to and down from the high-level footways are actuated hydraulically.

Dock gates are opened and closed by hydraulic rams, arranged horizontally, and connected with chains to the gates. In other cases the chains are wound on to, or unwound from, drums by hydraulic engines. Docks having openings as wide as 100 ft. have their gates opened and closed thus by pressure-water.

Big guns are also manipulated hydraulically, and the recoil also taken thus.

Mention has been made of the hydraulic punch, the shearing and flanging machines, but these are only faintly representative of the vast utilities of the pressure-water in our factories and on public works. Numbers of distinct and separate types of machine tools, some fixed, others portable, are in use in nearly every big engineers' works and on great public structures. A modern boiler is never built without the aid of these tools; seldom, if ever, is a bridge erected or a steel ship constructed without their having a big share in the work. It would be difficult to say which is the more useful—the heavy, fixed machines, or the lighter, portable kinds. The latter enable many operations to be performed that a few years ago were deemed impossible except by hand work—operations done in awkward situations and where the work is too massive to be taken to any machine. Holes are punched and drilled, rivets closed, and steel cut, control being exercised by the movements of simple valves operated by handles. But the power behind it all is the pressure-pump and the accumulator, with its storage.

JOSEPH G. HORNER

Latin : Important Idioms. English : Parsing and Analysis.
French : Numerals. German : Strong Verbs and Adverbs.

LATIN

Continued from page 1372

By Gerald K. Hibbert, M.A.

SECTION I.

Miscellaneous Idioms

English.	*Latin.*
Calpurnia married Cæsar.	Calpurnia Cæsari nupsit (lit., *veiled herself for Cæsar*).
Cæsar married Calpurnia.	Cæsar Calpurniam in matrimonium duxit.
He is the best scholar in the school.	Discipulorum, si quis alius, ille optime discit.
It does not fall to the lot of everybody to visit Naples.	Non cuilibet contingit Neapolim videre.
There are some who think you are mad.	Sunt qui putent te insanire.
I prefer a thousand deaths.	Malo sexcenties mori (the Latins always said *six hundred times* in such sentences).
I fear you are wrong.	Timeo ne erres.
I fear you are not wrong.	Timeo ut erres.
I will do it if I can.	Hoc si *potero* (*fut.*) faciam.
He pities no one.	Nullius miseretur (not *neminis*: gen. and abl. of *nemo* not used. "With *nemo* let me never see *Neminis* and *nemine*.")
I am sorry to say this.	Invitus hoc dico.
He perished in his youth.	Juvenis mortuus est.
I have asked him to come to see me as quickly as possible.	Rogavi eum ut quam celerrime veniat me visum (*supine*).
I cannot write for weeping.	Præ lacrimis scribere non possum.
One uses one tent, another another.	Alius alio tabernaculo utitur.
All the best citizens are present.	Optimus quisque civis adest.
It is all over with me.	Actum est de me.
You ought to have done it before.	Antea te hoc facere oportuit (*note the pres. infinitive*).
On the march.	Ex itinere.
On horseback.	Ex equo.
He departed without asking what I had done.	Discessit, neque quid fecissem rogavit (*or*, Ita discessit ut non rogaret, etc.). But not *sine* with gerund.

English.	*Latin.*
With your usual kindness.	Pro tua clementia.
In front was the sea, in our rear the enemy.	A fronte mare, hostes a tergo imminebant. (Note the "back to back" construction, called Chiasmus, *mare* and *hostes* being the two means, *a fronte* and *a tergo* the extremes).
He came sooner than he was expected.	Opinione celerius venit.
The House divided on the motion.	Pedibus in sententiam iverunt.
Once every four years.	Quarto quoque anno.
I am on the point of going.	In eo sum ut proficiscar.
In the open air.	Sub divo.
The sisters loved one another.	Sorores altera alteram amaverunt.
I was within an inch of death.	Minimum abfuit quin morerer.
Mind you come.	Cura (*or* Fac) ut venias, *or simply* Cura venias. (*Cura* is imperative of *curo*, *curare*.)
He is not a fit person for you to converse with.	Non est aptus quocum colloquaris.
I cannot walk even a mile, not to mention seven.	Ne mille passus quidem ambulare possum, nedum septem (millia passuum).
At one time he is wise, at another a perfect fool.	Modo sapiens, modo stultissimus est.
Some laws were passed, others remained posted up.	Leges aliæ latæ sunt, aliæ promulgatæ fuerunt.
What is the meaning of the word pleasure ?	Quid vult vox voluptatis ?
I asked him what time it was, but he made me no reply.	Mihi interroganti quota hora esset, nihil respondit.
I am writing this letter on the 1st of April.	Has literas (*or* hanc epistolam) Kalendis Aprilibus scribebam. (Epistolary imperfect, because to the reader the writing is *past*.)
It would be tedious.	Longum est.
It would have been better.	Melius fuit.

English.	*Latin.*
All the world knows that you are not convinced.	Nemo est quin sciat tibi non persuasum esse.
Instead of thanking me, he abused me.	Quum gratias mihi agere deberet, mihi maledixit.
"This, then, is the reason why pay has been granted to the soldiers: nor has it escaped our notice that this gift will be daubed with the poison of our enemies. The liberty of the people has been sold: our soldiery is removed for ever and banished from the city and from the republic: no longer do they give way even for winter or the season of the year and visit their homes and possessions. What do you think is the reason for this prolonged service?"	*In Oratio Obliqua.* Hoc illud esse quod æra militibus sint constituta; nec se fefellisse, id donum inimicorum veneno illitum fore. Venîsse libertatem plebis; remotam in perpetuum et ablegatam ab urbe et ab republica juventutem jam ne hiemi quidem aut tempori anni cedere ac domos ac res invisere suas. Quam putarent continuatæ militiæ causam esse? (Livy.)
The top of the mountain.	Summus mons.
From day to day.	Diem de die.
To be brief.	Quid plura [dicam]?
As far as I know.	Quod sciam.
No letter from you.	Nulla tua epistola.
Every fifth year.	Quinto quoque anno.
To make many promises.	Multa polliceri.

Section II.

Definitions of Grammatical Terms

Asyndeton. The annexing of words without a conjunction—*e.g.*, *di, homines* (gods and men).

Aposiopesis. A sudden stopping on the part of the speaker, as though unwilling or unable to proceed—*e.g.*, Æneid I., 135:

"*Quos ego—sed motos præstat componere fluctus.*"

Hendiadys. The presentation of one and the same notion in two expressions—*e.g.*, "with might and main." *Chlamydem sinūsque* (the folds of the cloak: literally, the cloak and the folds).

Enclitic. A word or particle which always follows another word, so united to it as to seem a part of it—*e.g.*, -que, -ve.

Patronymic. A title expressing descent from a father or ancestor—*e.g.*, *Alcides* = son of Alceus; *Anchisiades* = son of Anchises.

Syncope. The shortening of a word by casting out an inner vowel; as, *patri* (*pateri*).

Synesis. A construction in harmony with the sense rather than with strict syntax—*e.g.*, *subeunt juventus auxilio tardi* = the young men come up slowly to the rescue. Here *subit* and *tarda* would have been strictly needed.

Crasis. The contraction of two vowels into one long vowel or into a diphthong.

Zeugma. The using of one verb in two different senses—*e.g.*, Æn. I., 264: *mores et mœnia ponet.*

Oxymoron. An apparent contradiction in terms—*e.g.*, *splendide mendax: insepultam sepulturam* (a mockery of burial).

Periphrastic Conjugation. The participles in *urus, dus* may be conjugated with all the tenses of *sum*—*e.g.*, to form fut. subj. of *amo*, "*amaturus sim.*"

Litotes. Understatement, saying less than one means—*e.g.*, "a citizen of no mean city," *non innoxia verba* (deadly words).

Hysteron-Proteron. The idea, logically second, being put first—*e.g.*, *moriamur, et in media arma ruamus.*

Chiasmus. Contrast obtained by reverse order—*e.g.*, *urbi Cæsarem, Brutum Galliæ* (*dederunt*).

Anaphora. Repetition of the verb to avoid the use of a conjunction—*e.g.*, *Venit et upilio; tardi venere subulci* (Virgil, Eclogues X., 19).

Passage to be rendered into Latin

A CHARACTER SKETCH.

He belonged to those thin and pale men, as Cæsar names them, who sleep not in the night and who think too much; before whom the most fearless of all hearts has shaken. The quiet peacefulness of a face, always the same, hid a busy, fiery soul, which stirred not even the veil behind which it worked, and was equally inaccessible to cunning or love; and a manifold, formidable, never-tiring mind, sufficiently soft and yielding momentarily to melt into every form, but sufficiently proved to lose itself in none, and strong enough to bear every change of fortune. None was a greater master than he in seeing through mankind and in winning ón hearts; not that he let his lips, after the manner of the court, confess a bondage to which the proud heart gave the lie; but because he was neither covetous nor extravagant in the marks of his favour and esteem, and by a prudent economy in those means through which one binds men, he multiplied his real store of them. Did his mind bear slowly, so were its fruits perfect; did his resolve ripen late, so was it firmly and unshakably fulfilled. The plan to which he once had paid homage as the first, no resistance would tire, no chances destroy; for they had all stood before his soul, before they really took place. As much as his mind was raised above terror and joy, so much was it subjected to fear; but his fear was there earlier than the danger, and in the tumult he was tranquil because he had trembled when at rest.

Latin Version of the above Passage.

Erat profecto e pallidis illis macilentisque viris quos dicit Cæsar [*or*, ut Cæsarianum illud usurpem] qui insomnia et nimia cogitatione exerciti terrorem aliquando vel fortissimis incusserunt. Vultui tranquillo et immobili suberat acer fervidusque animus, qui ne involucrum quidem sibi operanti quasi prætentum commovebat, contra fraudem et studia pariter obstinatus: suberat ingenium multiplex, formidulosum, indefessum, ita facile ut nullam non ex tempore formam indueret, ita duratum

ut nunquam a sua ipsius natura decederet, ita validum ut omnes fortunæ vicissitudines impune sustineret. Hominum indoles, ut nemo alius, perspiciebat, conciliabat gratiam: quem tamen ne putes, urbanorum more, obsequium, quod infitiaretur contemptor animus, ore professum esse, sed potius officiosæ benevolentiæ neque parcum neque prodigum, opes, quibus devinciuntur homines, caute dispensando auxisse. Mens ejus, si tardiores, perfectos certe edebat fructus; consilia ut serius provenissent, constanter tamen et sine vacillatione peragebantur. Propositum, cui semel primas detulisset, nulla vis oppugnantium frangere, nullæ vices labefactare poterant, quippe quas omnes animo jamdudum præcepisset. Quantum super terrores et gaudia elata erat mens ejus, tantum timori erat subjecta: præveniebat vero timor ille periculum, adeo ut qui in tranquillo trepidavisset, in trepidatione ceterorum maneret tranquillus.—(J. Conington.)

Section III. TRANSLATION.

Passage from Virgil's Eclogues, or Pastoral Poems.

"THE GOLDEN AGE."

[*Virgil expresses the general hopes of a new era of peace and prosperity in language suggestive of the return of a bygone age of gold, connecting this age with the birth of a boy expected in this year*, B.C. 40.]

At tibi prima, puer, nullo munuscula cultu
Errantes hederas passim cum baccare tellus
Mixtaque ridenti colocasia fundet acantho.
Ipsæ lacte domum referent distenta capellæ
Ubera, nec magnos metuent armenta leones.
Ipsa tibi blandos fundent cunabula flores.
Occidet et serpens, et fallax herba veneni
Occidet; Assyrium vulgo nascetur amomum.
At simul heroum laudes et facta parentis
Jam legere et quæ sit poteris cognoscere virtus,
Molli paulatim flavescet campus arista,
Incultisque rubens pendebit sentibus uva,
Et duræ quercus sudabunt roscida mella.
Pauca tamen suberunt priscæ vestigia fraudis,
Quæ tentare Thetim ratibus, quæ cingere muris
Oppida, quæ jubeant telluri infindere sulcos.
Alter erit tum Tiphys, et altera quæ vehat Argo
Delectos heroas; erunt etiam altera bella,
Atque iterum ad Trojam magnus mittetur Achilles.
Hinc, ubi jam firmata virum te fecerit ætas,
Cedet et ipse mari vector, nec nautica pinus
Mutabit merces: omnis feret omnia tellus.
Non rastros patietur humus, non vinea falcem;
Robustus quoque jam tauris juga solvet arator;
Nec varios discet mentiri lana colores,
Ipse sed in pratis aries jam suave rubenti
Murice, jam croceo mutabit vellera luto:
Sponte sua sandyx pascentes vestiet agnos.
'Talia sæcla,' suis dixerunt, 'currite' fusis
Concordes stabili fatorum numine Parcæ.

Translation of the above Passage.

On thee, child, the earth shall begin to lavish without aught of tillage her simple gifts, straggling ivy twined with foxglove, and colocasia (the Egyptian bean) with smiling bear's-foot. Of their own accord the she-goats shall bring home their udders swollen with milk, and the herds shall not dread the mighty lions. Thy very cradle shall pour forth flowers to caress thee. The serpent, too, shall perish; perish likewise the treacherous poison-plant. Eastern spice shall spring up everywhere. But so soon as thou shalt be able to learn the exploits of heroes and the deeds of thy father and what their manly virtue is, gradually the plain shall turn yellow with waving corn; on wild brambles shall hang the ruddy grape, and sturdy oaks exude the dew-born honey. Yet shall there lurk a few traces of early guile, to bid men tempt the sea with barks, gird cities with walls, and cleave the earth with furrows. Then shall be a second Tiphys (helmsman of the Argo) and a second Argo to carry the chosen heroes; there shall be the old wars repeated and a great Achilles sent again to Troy. Next, when thy full-grown strength has made thee a man, even the merchant shall quit the sea, and the pine-built ship shall not exchange its wares: every land shall bring forth everything. The ground shall not endure the hoe, nor the vineyard the pruning-hook: the stout ploughman, too, shall now loose his oxen from the yoke. Wool shall not learn to assume divers colours, but by Nature's gift (ipse) the ram in the meadows shall exchange his fleece for sweetly-blushing purple and for saffron dye. Of its own accord scarlet shall clothe the browsing lambs. "Ages like these, run on!" said the Parcæ to their spindles, uttering in concert the fixed will of Fate.

Those desirous of pursuing Latin Prose further are recommended to use Abbott's "Latin Prose through English Idiom"; "Arnold's Latin Prose Composition," by Bradley; and "Translations," by Messrs. Jebb, Jackson, and Currey (George Bell and Sons), to all of which books, with the addition of Roby's Latin Grammar and the Public School Latin Primer, the writer wishes to acknowledge his indebtedness.

We now pass to a subject which requires a very careful study of Latin quantities—the making of Latin verse.

Continued

ENGLISH

Continued from page 1576

By Gerald K. Hibbert, M.A.

PARSING

We have now gone through all the parts of speech in detail, and have been "parsing" words, perhaps unconsciously, throughout the process. For to "parse" a word is simply to say to what part of speech it belongs, and how it is related to other words in the same sentence.

Parsing Scheme. 1. Noun. Give (1) general class—*i.e.*, proper, common, abstract,

collective; (2) gender; (3) number; (4) case; (5) reason for the case.

2. ADJECTIVE. Give (1) class, whether of quality, quantity, or relation; (2) degree, whether positive, comparative or superlative; (3) its qualification of the substantive. If the adjective in question is pronominal—*i.e.*, also used as a pronoun—state this in parsing it.

3. PRONOUN. Give (1) class, (2) gender (if possible), (3) number, (4) case, with reasons for the number and the case.

4. VERB. If a finite verb, give (1) voice, (2) mood, (3) tense, (4) number, (5) person, and the subject with which it agrees.

If an infinitive or gerund, give (1) voice, (2) tense, (3) case, with a reason for the case.

If a participle, give (1) voice, (2) tense, (3) number, (4) case, and the substantive with which it agrees.

In *all* moods, say whether the verb is transitive or intransitive, whether of weak conjugation or of strong, and give the principal parts of the verb—*i.e.*, present indicative, past indicative, and past participle.

5. ADVERB. Give (1) class, (2) degree, (3) what it qualifies.

6. PREPOSITION. State what it governs.

7. CONJUNCTION. Give its class, and say what sentences or words it connects.

Example of Parsing.

"But then the mind much sufferance doth o'erskip,
When grief hath mates, and bearing fellowship"
("King Lear.")

But. Co-ordinative conjunction, connecting this sentence with what has gone before.

Then. Adverb of time, modifying "doth o'erskip."

The. Demonstrative adjective, pointing out "mind" (sometimes called definite article).

Mind. Abstract noun, neuter, singular, nominative because subject of "doth o'erskip."

Much. Adjective of quantity, positive, qualifying with "sufferance."

Sufferance. Abstract noun, neuter, singular, objective, governed by "doth o'erskip."

Doth o'erskip. Verb, transitive, weak conjugation, active, indicative, present, singular, third person, agreeing with its subject "mind," from *o'erskip, o'erskipped, o'erskipped.*

When. Relative adverb (or conjunctive adverb) of time, modifying "hath."

Grief. Abstract noun, neuter, singular, nominative, because subject to "hath."

Hath. Verb, notional (not auxiliary here), transitive, weak, active, indicative, present, singular, third person, agreeing with its subject "grief," from *have, had, had.*

Mates. Common noun, common gender, plural, objective after "hath."

And. Co-ordinative conjunction, joining the two sentences "Grief hath mates," and "Bearing (hath) fellowship."

Bearing. Abstract noun, neuter, singular, nominative, subject to "hath" understood

Fellowship. Abstract noun, neuter, singular, objective after "hath" understood.

N B. Parse compound tenses of a verb—*e.g.*, *have been, shall be leaving,* all as one word. We could, of course, split them up and parse the words separately, but there is no need to do this.

ANALYSIS

Complex Sentences. The method of analysing simple sentences was given on page 788. When we analyse a complex sentence, we first pick out the principal clause, and insert the subordinate clauses as parts of the principal clause. Then we analyse the different subordinate clauses, omitting the connecting words.

For example:

"There is some soul of goodness in things evil
Would men observingly distil it out."

The principal clause is "There is some soul of goodness in things evil," and the subordinate clause "(If) men would observingly distil it out."

SUBJECT.	LIMITATION OF SUBJECT.	PREDICATE.	LIMITATION OF PREDICATE.	OBJECT.
soul	(*a*) some (*b*) of goodness	is	(*a*) in things evil (*b*) would men observingly distil it out	——
men	——	would distil	(*a*) observingly (*b*) out	it

Again:

"If you catch him when you reach home, give him the message which I will give you now."

The principal clause is "give him the message"; the other three clauses are subordinate.

1. Principal Clause

SUBJECT.	LIMITATION OF SUBJECT.	PREDICATE.	LIMITATION OF PREDICATE.	OBJECT.	LIMITATION OF OBJECT.
(you)	——	give	(*a*) him (*b*) if you catch him when you reach home	message	(*a*) the (*b*) which I will give you now

2. Subordinate Clauses

(*a*) If you catch him when you reach home.

you	—	catch	when you reach home	him	—

(*b*) When you reach home.

you	—	reach	home	—	—

(*c*) Which I will give you now.

I	—	will give	(*a*) You (*b*) now	which	—

Classification of Clauses. As has been mentioned previously, there are three kinds of clauses:

1. Clauses that play the part of a substantive in relation to some part of the sentence—*i.e.*, *Substantival* clauses.
2. Clauses that play the part of an adjective in relation to some part of the sentence—*i.e.*, *Adjectival* clauses.
3. Clauses that play the part of an adverb in relation to some part of the sentence—*i.e.*, *Adverbial* clauses.

Examples. SUBSTANTIVAL: "We know *that you are wrong*" (this clause is the object of "know"); "*When the election will come* is uncertain" (this clause is the subject of "is").

ADJECTIVAL: "Give me the portion of goods *that falleth to me*" (qualifies "portion"); "That is the spot *where Nelson fell*" (qualifies "spot"). Similarly with all clauses thus introduced by a relative pronoun (expressed or understood) or a relative adverb. Care must be taken, however, to distinguish such clauses from clauses involving an indirect question—as: "Tell me *where Nelson fell*," "I asked *where I was*," "I know *why you have come*." In these sentences the dependent clauses are substantival, representing substantives; there is no antecedent to which they can relate.

ADVERBIAL: "He died *while I was standing by*" (qualifying "died"); "We love Him *because He first loved us*" (modifying "love"); "Do *as I tell you*" (modifying "do").

EXERCISE.

Classify the subordinate clauses in the following extract from Scott's "Lay of the Last Minstrel," and parse the words in italics.

"But when he reached the hall of state,
Where she and all her ladies *sate*,
Perchance he wished the boon *denied*;
For, when to tune his *harp* he tried,
His *trembling* hand had lost the ease
Which marks security to please."

We conclude this course with a brief survey of the history of the English language.

Continued

FRENCH

Continued from page 1578

By Louis A. Barbé, B.A.

NUMERALS

1. Cardinal Numbers

1. The cardinal numbers (*adjectifs numéraux cardinaux*) are:

0, zéro
1 un
2, deux
3, trois
4, quatre
5, cinq
6, six
7, sept
8, huit
9, neuf
10, dix
11, onze
12, douze
13, treize
14, quatorze
15, quinze
16, seize
17, dix-sept
18, dix-huit
19, dix-neuf
20, vingt
21, vingt et un
22, vingt-deux
23, vingt-trois, etc.
30, trente
31, trente et un
32, trente-deux
33, trente-trois, etc.
40, quarante
41, quarante et un
42, quarante-deux
43, quarante-trois, etc.
50, cinquante
51, cinquante et un
52, cinquante-deux
53, cinquante-trois, etc.
60, soixante
61, soixante et un
62, soixante-deux
63, soixante-trois
64, soixante-quatre
65, soixante-cinq
66, soixante-six
67, soixante-sept
68, soixante-huit
69, soixante-neuf
70, soixante-dix
71, soixante et onze
72, soixante-douze
73, soixante-treize
74, soixante-quatorze
75, soixante-quinze
76, soixante-seize
77, soixante-dix-sept
78, soixante-dix-huit
79, soixante-dix-neuf
80, quatre-vingts
81, quatre-vingt-un
82, quatre-vingt-deux
83, quatre-vingt-trois
84, quatre-vingt-quatre
85, quatre-vingt-cinq
86, quatre-vingt-six
87, quatre-vingt-sept
88, quatre-vingt-huit
89, quatre-vingt-neuf
90, quatre-vingt-dix
91, quatre-vingt-onze
92, quatre-vingt-douze
93, quatre-vingt-treize
94, quatre-vingt-quatorze
95, quatre-vingt-quinze
96, quatre-vingt-seize
97, quatre-vingt-dix-sept
98, quatre-vingt-dix-huit
99, quatre-vingt-dix-neuf
100, cent
101, cent un
200, deux cents
201, deux cent un
1,000, mille
1,000,000, un million
1,000,000,000, un milliard

2. The old forms for 70, 80, 90, *septante*, *octante*, *nonante*, are seldom seen in print, but may occasionally be heard. Their derivatives:

septuagénaire, octogénaire, nonagénaire are still in common use to designate persons 70, 80, or 90 years of age. For *soixante* the corresponding form is *sexagénaire*.

3. The conjunction *et* is used in the first number of every new decade from *vingt et un*, 21, to *soixante et onze*. 71. It is not used after *cent*, hundred; *cent cinq*, 105; *cent vingt*, 120; but by some it is again used after *mille*, 1,000: *les Mille et une Nuits*, the Thousand and One Nights.

4. No preposition must be placed between the cardinal number and a noun; but *de* is required after *million* and *milliard*, which are really nouns: *Deux millions de francs*. For this reason they have *un* before them when used in the singular, and they take *s* when in the plural. *Cent* and *mille* are occasionally used as nouns of measure, and then follow the same rule: *deux cents de poires, un mille de fagots*.

5. *Vingt*, twenty, and *cent*, hundred, take *s* when they are multiplied by a number, but not followed by one. As regards *vingt*, *s* occurs in the one number 80 only: *quatre-vingts, deux cents*; but *quatre-vingt-un, deux cent deux*.

6. When *vingt* and *cent* are used as ordinal numbers, or when they occur in dates, they do not take *s*: *l'an quatre-vingt*, the year 80; *l'an huit cent*, the year 800; *page quatre-vingt*, page 80; *page deux cent*, page 200.

7. When the word thousand occurs in a date of the Christian era, and is followed by another number, it is written *mil*: *mil neuf cent cinq*, 1905; but *l'an mille*, the year 1000.

8. The cardinal numbers, and not the ordinal as in English, are used to indicate the order of succession of sovereigns and the days of the month, after the first: *Charles deux, Henri quatre, le trente juillet, le quinze novembre*. In indicating the order of sovereigns, no article is used before the numeral. In indicating the day of the month, an article is used before the numeral, but no preposition after it.

9. In dating letters, figures are commonly used. The use of the article before them is optional. Sometimes *ce* (this) is used. Thus:

London, May 28th: *Londres, 28 mai. Londres, le 28 mai. Londres, ce 28 mai.*

10. In indicating the hour of the day, "twelve" is not used. *Midi* (midday), and *minuit* (midnight) are used instead.

11. In multiplying and adding, the verb *faire* (to make) is used instead of "to be."

Deux fois deux font quatre.
Twice (two times) two are four.
Neuf et sept font seize.
Nine and seven are sixteen.

II. Ordinal Numbers

1. The ordinal numbers (*adjectifs numéraux ordinaux*) are formed from the cardinals by adding *ième*: *troisième*, third; *huitième*, eighth.

2. If the cardinal number ends in *e*, that *e* is omitted. The *s* of *quatre-vingts* is also dropped, *quatrième*, 4th; *onzième*, 11th; *quatre-vingtième*, 80th.

3. "First" is *premier*; but the regular form, *unième* is used for the first of every decade from 21st to 61st, and also after *cent* and *mille*. *Vingt et unième, trente et unième, cent et unième, mille et unième.*

4. "Second" has the two forms *second*, (fem. *seconde*) and *deuxième*. *Second* is used of the *second* of two, *deuxième* of the second in a longer series.

5. In "fifth" the *u* which is the only vowel that can follow *q* is inserted: *cinquième*.

6. In "ninth," the final *f* of *neuf* is changed into *v*: *neuvième*.

7. *Premier* is used for "first" in indicating the order of sovereigns and the day of the month: *Charles premier, le premier janvier*; but *le vingt et un juillet, le trente et un août*.

8. A special ordinal, *le quantième* (literally, the "how-*manieth*") is used for "the day of the month"; thus: *Quel est le quantième?* What day of the month is it?

III. Fractions

1. The ordinal numbers are used as fractions, except in the case of $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{1}{4}$, $\frac{3}{4}$. Thus: *un sixième*, $\frac{1}{6}$; *deux cinquièmes*, $\frac{2}{5}$.

2. "Half" is *demi*. It is masculine as an arithmetical value. When preceding a noun it is joined to it by a hyphen, and is invariable: *une demi-bouteille*, half-a-bottle. When it follows the noun it agrees with it in gender: *une bouteille et demie*, a bottle and a half; *trois heures et demie*, three hours and a half. As a noun, "half" is *moitié*: *la moitié de la nuit*.

3. The "thirds" are *un tiers, deux tiers*; the "quarters" are *un quart, trois quarts*.

Exercise XII.

1. Write out in French: 3, 5, 7, 11, 12, 15, 19, 21, 22, 30, 31, 44, 55, 58, 60, 69, 70, 71, 80, 89, 91, 99, 100, 210, 350, 789, 911, 999, 1,234.

2. Give French for: 1st, 2nd, (two ways), 4th, 5th, 9th, 20th, 21st, 32nd, 45th, 51st, 66th, 70th, 71st, 80th, 81st, 89th, 90th, 91st, 99th, 100th.

3. 1 and 1 are 2, and 2 are 4, and 4 are 8, and 8 are 16, and 16 are 32, and 32 are 64, and 64 are 128.

4. Twice 1 are 2; 3 times 2 are 6; 4 times 6 are 24; 5 times 24 are 120.

5. The minute contains (*contient*) 60 seconds.

6. The second is the 60th part (*partie*) of a minute.

7. (The) light takes (*emploie*) 8 minutes 13 seconds to come (*venir*) from the sun.

8. In an hour there are 60 minutes.

9. The day is a period (*espace*, m.) of 24 hours.

10. From midnight to midday there are 12 hours.

11. The year is composed of 365 days and a quarter.

12. The week (*semaine*, f.) has 7 days; the month has sometimes (*quelquefois*) 31 days, sometimes 30 days, and sometimes 28 only (*seulement*).

13. The month of February, the second month of the year, has 28 days.

14. The year begins (on) the 1st of January; it finishes (*finit*) on the 31st of December.

15. The month of December is the last month of the year.

16. The feast of Christmas falls always (on) the 25th of December.

Continued

 Continued from page 1450 By P. G. KONODY and Dr. OSTEN

XVIII. In the STRONG CONJUGATION OF VERBS [see X.] the characteristic features are the formation of the *imperfect* by *changing the stem-vowel*, and of the *past participle* by the suffix -en or -n with or without change of the stem-vowel, and with or without the prefix ge- [see XIV.]. The stem-vowel is also changed or modified in some cases of the *present indicative* and in the *imperfect conjunctive*.

1. The *present tense* of the verb schreiben, to write, may serve as an example for the inflections of the strong verb.

		Indicative		*Conjunctive*
Sing.	1.	ich schreib-e	I write	ich schreib-e
	2.	du schreib-(e)st	thou writest	du schreib-est
	3.	er schreib-(e)t	he writes	er schreib-e
Plur.	1.	wir schreib-en	we write	wir schreib-en
	2.	ihr schreib-et	you write	ihr schreib-et
	3.	sie schreib-en	they write	sie schreib-en

In the conjunctive the flective e can never be dropped; it is also better to retain it in the second person indicative of verbs with stems ending in hissing sounds: s, ss, sch, z, where the omission would cause harshness—for instance: du schieß-est, thou shootest, and so on. In some of these verbs *both* forms are used, as: 1. ich vergesse, I forget; 2. du vergiss-est, du vergiß-t, and so on.

2. The majority of verbs with the stem-vowel a, au, and some with o (*a*) modify it, and others (*b*) change the stem-vowel e into i or ie in the second and third person singular of the indicative, and cast off the flective e.

EXAMPLES: (*a*) 1. ich grabe, I dig; 2. du gräbst; 3. er gräbt. 1. ich fange, I catch; 2. du fängst; 3. er fängt. 1. ich laufe, I run; 2. du läufst; 3. er läuft, etc. (*b*) 1. ich fechte, I fence; 2. du fichst; 3. er ficht. 1. ich gebe, I give; 2. du giebst; 3. er giebt. (The conjunctive remains unaltered: 1. ich grabe; 2. du grabest; 3. er grabe, and so on.)

3. Several of the verbs mentioned in 2, with stems ending in t, th, and d, drop not only the flective e, but also the t of the inflection of the third person singular indicative: 1. ich rathe, I advise; 2. du räth(e)st; 3. er räth, and so on.

4. The *imperative* of the *strong verbs* is formed as in the weak conjugation [see XIV. 3]: 2nd per. sing. bleib(e)! stay, remain! 2nd per. sing. schreib! write! Civil address: bleiben Sie! stay! schreiben Sie! write!

The verbs with the stem-vowel e change it in the singular into i or ie without suffix: fecht-en, to fence, ficht! geb-en, to give, gieb! ess-en, to eat, iß! and so on. The circumscribed forms of the imperative are formed as in the weak conjugation [see XIV. 4. 5].

XIX. The IMPERFECT INDICATIVE of the strong verbs is formed by changing the vowel in all persons and numbers; a further change of the *changed* vowel takes place in the past participle. The third person singular of the imperfect indicative takes no inflection, and the second person takes the inflection -est (after hissing sounds) or st: blas-en, to blow, 2nd pers. sing. du blies-est, thou blewest; but: bleib-en, 2nd pers. sing. du blieb-st. The inflections of the plural (1. -en, 2. -et, 3. -en) are to be seen below in the conjugation of the imperfect of sing-en, to sing, which belongs to the group of verbs that change their vowel -i- in the imperfect into -a-, and change it further into -u- in the past participle with the suffix -en and the usual prefix ge-. The present, imperfect, and past participle of singen are: *pres.*: (ich) sing-e; *imp.*: (ich) sang; *p. past*: ge-sung-en.

IMPERFECT

		Indicative	*Conjunctive*
Sing.	1.	ich sang, I sang	ich säng-e
	2.	du sang-st	du säng-est
	3.	er sang	er säng-e
Plur.	1.	wir sang-en	wir säng-en
	2.	ihr sang-(e)t	ihr säng-et
	3.	sie sang-en	sie säng-en

1. In the CONJUNCTIVE the verbs modify the vowels (a, o, u, or au) of the imperfect indicative, and take the same suffixes as the present tense of the conjunctive [see example and XVIII]. Some verbs with the imperfect vowel a are (*a*) alternately used with the modified ä and ö, and others (*b*) take the modification ü instead of ä. The form with ä in group (*a*) is usually not

IMPERFECT

	Infinitive	*Indicative*	*Conjunctive*
To (*a*) belong:	beginn-en, to begin	ich begann	ich begänn-e or begönn-e
	besinn-en, to reflect	„ besann	„ besänn-e or besönn-e
	gelt-en, to be worth	„ galt	„ gält-e or gölt-e
	gewinn-en, to win	„ gewann	„ gewänn-e or gewönn-e
	spinn-en, to spin	„ spann	„ spänn-e or spönn-e
	schwimm-en, to swim	„ schwamm	„ schwämm-e or schwömm-e
	rinn-en to flow	„ rann	„ ränn-e or rönn-e
	befehl-en, to command	„ befahl	„ befähl-e or beföhl-e
	empfehl-en, to recommend	„ empfahl	„ empfähl-e or empföhl-e
	stehl-en, to steal	„ stahl	„ stähl-e or stöhl-e
	schelt-en, to scold	„ schalt	„ schält-e or schölt-e
(exception)	steh-en, to stand	„ stand	„ ständ-e or stünd-e
to (*b*) belong:	helf-en, to help	„ half	ich hülf-e
	sterb-en, to die	„ starb	„ stürb-e
	verderb-en, to spoil	„ verdarb	„ verdürb-e
	werb-en, to enlist	„ warb	„ würb-e
	werd-en, to become	„ ward	„ würd-e
	werf-en, to throw	„ warf	„ würf-e

employed where, in the pronunciation, the phonetic similarity of the imperfect conjunctive with other tenses of the same verb might lead to confusion, as in ich befähle, empfähle, stähle, schälte, which sound similar to ich befehle, empfehle, stehle, schelte. For the same reason the form with å has been entirely abandoned in group (*b*).

2. Verbs which admit of *no modification* of the changed indicative vowel in the conjunctive form this tense by the suffixes shown in the conjugational example of XIX.

EXAMPLES: schreiben, imperfect indicative ich schrieb (ie not modifiable); imperfect conjunctive ich schrieb-e, etc.; beißen, to bite, imperfect indicative ich biß (i not modifiable); imperfect conjunctive ich biß-e.

Where the modified conjunctive vowel coincides with another tense, it is best to use the *first conditional* [see page 651] in the place of the imperfect conjunctive—*e.g.*, in the verb schwö-ren, to vow [imperfect indicative ich schwor (or schwur)]; the imperfect conjunctive, with modification of the vowel, ich schwör-e (or ich schwür-e) coincides with the present indicative. 1. ich schwör-e; 2. du schwör-st, etc. The employment of the first conditional „ich würde schwören" [infinitive of the verb and imperfect conjunctive of the auxiliary verb „werden"] [see page 651] prevents misunderstanding.

XX. The ADVERBS are not, of course, subject to inflection by declension or conjugation.

Adverbs of place: hier, da, here; dort, da, there; oben, above; unten, below; vorn, in front, before; hinten, behind, after; innen, within; außen, out, without; fort, away, forth; weg, away, off; heraus', out; hin'ein, in, into; vor'wärts, forward, on; rück'wärts, backwards.

Adverbs of time: wann? when? dann, then; jetzt, now; soeben, just now; heu'te, to-day; ge'stern, yesterday; einst, once; da'mals, then, at that time; immer, stets, always, ever; selten, rarely; nie, nie'mals, never; zuwei'len, sometimes; schon, already; noch, still, yet; hierauf, hereon, hereupon; nun, now, at present.

Adverbs of manner, degree, quality, affirmation, negation, like: so, so, thus; sehr, very; ziemlich, tolerably, pretty; wenig, little, few; meist, meistens, most, mostly; umsonst', in vain; fer'ner, furthermore, besides; fast, beina'he, almost, nearly; kaum, scarcely; ganz, quite; nur, only, but; allerdings', surely, certainly; keinesfalls, keineswegs, by no means; vielleicht', perhaps; ungefähr, about; ja, yes; nein, no; nicht, not.

Adverbs of cause: darum, deshalb, therefore; folg'lich, consequently; also, thus; daher', thence; warum', wozu'? why?

1. Nearly all adjectives can be used adverbially without undergoing any change of form. In the sentence: Der Gärtner ist fleißig (the gardener is diligent) the adjective fleißig qualifies the substantive; whilst in der Gärtner a r b e i t e t fleißig (the gardener *works* diligent*ly*), it modifies as *adverb* the action expressed by the *verb*.

Some adverbs and adverbial denotations are formed from substantives, adjectives, and verbs by the suffixes -s, -st, -lich, -lings, etc.; (abends, or des Abends in the evening, of an evening; morgens, in the morning; jüngst, lately; freilich, certainly, indeed; neulich, recently; begreiflich, conceivably; meuchlings, treacherously; blindlings, blindly; etc.), or by connection with prepositions.

2 If a sentence opens with an adverb, the normal position of the finite verb is changed—the verb in this case must precede the subject. Examples: ich bin hier (I am here), but hier bin ich; er kommt nie (he never comes), but nie kommt er; der Gärtner arbeitet fleißig, but fleißig arbeitet der Gärtner. It will be seen that verb and subject are here in the same relative position as in the interrogative form [see IX.].

3. Some adverbs admit the use of the comparative and superlative, like the adjectives, but the formation of the adverbial superlative differs from the superlative in adjectives, as will be seen later.

EXERCISE 1: Fill in the missing verbs with their correct personal terminations. Strong verbs used in this Exercise (the imperfect vowel in brackets); beißen (i), to bite; betrügen (o), to cheat; binden (a), to bind; geben (a), to give; fahren (u), to drive; schlafen (ie), to sleep; laufen (ie), to run; helfen (a), to help; rufen (ie), to call; fechten (o), to fight; graben (u), to dig; fliehen (o), to escape.

Der Hund . . . . . ; er . . . . seinen Herrn. Du . . . . . .
The dog bites; he bit his master. Thou cheatest

dich selbst: Sie . . . . . . mich. Du . . . . . . Blumen;
thyself; you cheated me. Thou bindest flowers;

das Mädchen . . . . einen Kranz; der Vertrag . . . . ihn.
the girl bound a wreath; the agreement binds him.

Ich . . . . . ihm Geld, und er . . . . . . fort;
I gave him money, and he drove away;

ich . . . . . nichts; du . . . . . . mir das Geld,
I give nothing; thou givest me the money,

und er . . . . . . dir den Vertrag. Wir . . . . .
and he gives thee the agreement. We drove

fort und . . . . . .; ihr . . . . . . ihn, aber er . . . . . .;
away and slept: you called him. but he slept;

du . . . . vorzüglich. Ich . . . . und er . . . .
thou sleepest excellently. I drove and he ran

fort. Du . . . . . . mich. Wir . . . . . . die
away. Thou scoldest me. We bound the

Blumen und ihr . . . . . uns. Wir . . . . . euch Alles,
flowers and you helped us. We gave you all,

doch ihr . . . . . . uns nichts; Sie . . . . . ., während
but you gave us nothing; you fought, whilst

ich . . . . . Er . . . . . mir und dann . . . . . . fort;
I slept. He helped me and then drove away;

du . . . . gut; er . . . . . . vorzüglich;
thou fightest well; he fights excellently;

ihr . . . . tapfer. Er . . . . . . mit (3) ihm
you (*pl.*) fight bravely. He drives with him

und . . . . . den Gärtner; sie . . . . . . mit ihm;
and calls the gardener; she escaped with him;

Sie . . . . . den Gärtner und . . . . . . ihm Geld;
you called the gardener and gave him money;

sie . . . . . . ihrem Manne; sie . . . . . . einander;
she helps her husband; they help one another,

Sie . . . . . ., du . . . . . ., er . . . . ., wir . . . . .,
you (*pl.*) sleep, thou drivest, he runs, we dig,

Continued

Essential Qualifications of a Good Milliner. The Apprentice. Importance of Suiting a Customer's Style. Stitches and Accessories.

MILLINERY

MILLINERY is essentially a woman's profession, but to be successful she must have a light and delicate touch, accuracy and neatness, good taste in blending colours, a correct eye, judgment in adapting the style to the wearer, and a liking for working with dainty and pretty materials. Few tools are needed.

There are two seasons in the millinery trade, spring and autumn, with six to eight slack weeks in the summer and winter—July and August, and December and January.

The Apprentice. A girl of about 16, wishing to become a milliner, is usually apprenticed. The period is two years, in the second of which she receives about half-a-crown a week pocket-money. In some houses a premium is asked; others take girls without a premium, but through introduction. The girl is taken on approbation for some weeks to see if she has the necessary qualifications. At the end of the two years, if she has given satisfaction, she is usually taken on as improver, with a weekly salary starting generally at about 15s. a week. In the slack time some houses work their apprentices half time, or give them a holiday till the next season opens.

The head assistants and head milliners are engaged by the year, with salaries varying between two and five guineas a week.

It is well for a girl to be apprenticed to a small business, although it should be a first-class one, as she will then have a good opportunity of seeing all kinds of work done. In the larger houses the work is divided up into different branches, one room being set aside for making hats, another for toques and bonnets, and so on. An apprentice will never regret the time spent in matching—that is, obtaining from the warehouses patterns of silks, velvets, ribbons, etc., which tone exactly with a particular pattern. Until one has tried, it is difficult to realise how difficult some colours are to blend.

Advising a Customer. A milliner who thoroughly understands her work is able to advise her customers which of the many prevailing styles suits her, and a good business woman is sure to be a success.

Though the fashions change so rapidly many of the principles never change, and, when mastered, the worker will find herself able to adapt them to prevailing fashions.

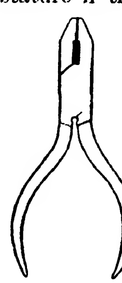
The importance of wearing what is really becoming without considering whether it is the latest fashion or not cannot be over-estimated. A clever milliner's aim is to adapt the prevailing fashions to suit the face.

Modern styles are so elastic that it is perfectly easy to be well dressed. No rules on how to dress can be laid down, but an important point to remember is that in choosing a hat or toque it is not only well to decide with what costume it will be worn, but, if possible, to try it on when wearing the dress. It will avoid possible disappointment, as that which looks well and in perfect style with a tailor-made costume may look small and insignificant when worn with an elaborately trimmed dress or big furs.

Hair-dressing and Millinery. The way in which the hair is dressed is another consideration in the choosing of headgear. The most fashionable headgear is modelled on the way the hair is dressed at the moment; thus, if the hair is worn low down at the neck, the brims will be long at the back. When the hair is worn at the top of the head, a short brim at the back with high crown, or a low crown and bandeau, looks best. For hair worn rolled back from the face, a turned up brim in front is most suitable.

Thin faces should have the hair dressed loosely over the temples, and a soft-looking edge to hat or full front to a bonnet. When no fringe is worn and the hair brushed smoothly back, a bonnet with rucked edge, or a brimmed hat, will be the best style to adopt. Hair dressed in coils and plaits at the back usually requires a large headline. Coils and plaits round the front require the headline cut rather wide there.

Large picture hats look well on tall people, though they may be worn by persons of small stature if trimmed very lightly. A hat should *never* be over trimmed.



1. WIRE NIPPERS

A full face needs a broad trimmed hat.

A long face looks best in a brimmed hat, trimmed broad and worn over the face. High trimmings, which lengthen the face, should be avoided. Broad toques, fitting well on the head, may be worn.

The most becoming hat for a round face is a round hat with an equal brim all round, except at the back, and worn tilted slightly off the face in the front. No very small hats or toques are becoming to this style of face.

Drooping brims of the flop and mushroom type are not becoming to people past their youth, as they cast a shadow on the face. They are best suited to young, round faces.

Brims turned up in front can be worn by small round and oval faces.

Let your customer wear the colours that suit her. Do not advise her to wear a colour that

does not match her complexion, hair and eyes, no matter how fashionable.

The blonde may wear delicate shades of blue, pink, and green.

The brunette looks well in deeper and richer colours.

The choice of shades depends greatly on the complexion, as the colour may suit the hair but not the skin.

White is very becoming to fresh and rosy skins, but should be avoided by those with pale and sallow complexions.

Black is not becoming to pale and sallow complexions, unless combined with lace and a colour in the trimming. It looks well on fair people with a little colour in the face.

Requisites. We must now consider a milliner's "tools."

Gum or Gum Labels.

Tissue Paper.

Bowl and Damping Rags. For steaming and pressing.

Notebook and Pencil. For writing down measurements.

French "Doll's Head." Used for cap-stand.

Block for Shaping Crowns.

Kilting Machine.

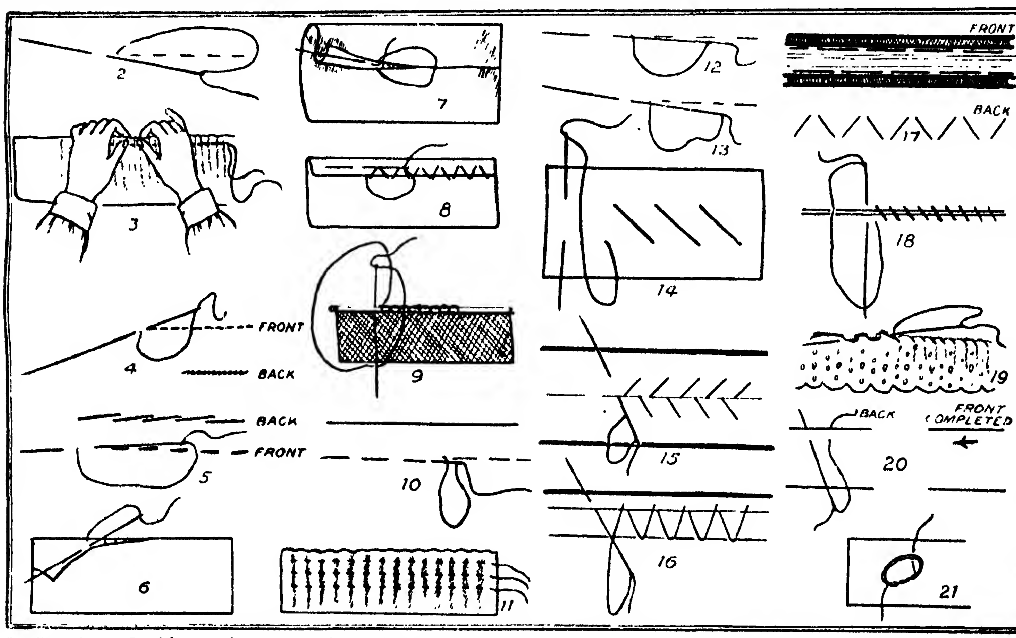
Accordion Pleating Machine.

Pinking Machine.

Velvet Brush.

Stitches. The following are the stitches used in millinery:

Running. Pass the needle and cotton in and out of the material at equal distances. The stitch appears the same on both sides. Used



2. Running 3. Fly running 4. Back stitching 5. Long back stitching 6. Slip stitching 7. Slip hemming 8. Velvet hemming 9. Wire stitching 10. Gathering 11. Shirring 12. Tacking 13. Tacking for crape 14. Basting 15. Lacing stitch 16. Catch stitch 17. Straight bandeau 18. Oversewing 19. Whipping 20. Tie stitch 21. Stab stitch

Millinery Wire Nippers. Price 1s. to 2s. 6d.; the latter are made of English steel. They must be light, small, and with broad noses [1].

Needles. Packet of straw needles, mixed, sizes, 5, 6, 8. Price 1d. No. 5 for wiring, and No. 8 for hemming.

Steel Pins. For pinning silk, velvet, etc.

Lillikins. For pinning velvet edges, joining laces, etc.

Thimble.

Scissors. About 7 in. long, with sharp points.

Tape Measure. Dean's are the best.

Sewing Cotton. Fine and coarse, white and black, No. 10 for sewing on trimmings.

Sewing Machine.

Flat Irons. No. 2 and No. 8, for pressing straw and steaming velvet, etc.

Ironing Blanket. For pressing.

Pocket-knife. For ripping fur.

for making the hem of head-linings, and joining two parts together where no great strength is needed [2].

Fly-running. Place the needle in the material and hold it lightly, close to the point, with the right thumb and forefinger. The thimble should propel the needle. The left hand holds taut the material, which is pushed on the needle by the left thumb and forefinger. As the needle fills with material, push it off from the eye end. The needle is not drawn through until the whole length is gathered. For long lengths, thread the needle from the reel of cotton or silk, which will prevent it knotting [3]. It is a rapid way of running, and is used for all branches of millinery that require gathering, such as tuckings, casings for silk hats and bonnets, tuck running in chiffon, tulle, etc.

Back Stitch. Insert the needle exactly where the last stitch was begun, and bring it out in front the same length as the stitch that has just been made.

To obtain a regular row of stitches, each stitch must exactly meet the last, and be of the same size [4]. Used for joining two pieces of velvet, silk, or cloth, wherever the material is likely to be stretched and requires strength.

Long Back Stitch. Instead of inserting the needle in exactly the place where the last stitch left off, as in back stitching, take a short stitch back, which in straw-working will be slanting in the direction the straw is plaited [5]. The long back stitch is used in straw-working, for sewing in head linings, bandeaux, mulling; in shape-making, for joining side band to head-line of brim shape; in covering, for sewing upper and under covering of brim to head-line, also material tip to that of shape.

Slip Stitch. Take one stitch on the turning of one piece of material, and the next exactly opposite on the turning of the other piece [6]. Used for joining the upper and under edges of hat-brims covered in velvet, cloth, or silk, and wherever invisible joining is required; also in stitching on rouleau to covered or felt hats.

Slip Hemming. Use a fine needle and cotton, or silk to match material, and take up one thread of the material under the fold. Slip the needle into the fold and make a short stitch as in running; draw the needle out, and just take one thread again of the material under the fold. Do not pull the stitches tight; they should not show on the right side [7]. The stitch is used for invisibly hemming velvet, silk, crape, etc.

Velvet Hemming. Turn down the raw edges of material once; take a stitch as in running through the fold, and take one thread of the material under the fold in a slanting direction. Work from right to left with fine needle and cotton [8]. Used for neatening cut edges of velvet, and where it does not require a roll hem.

Wire Stitch. Hold the wire firmly in place, stab the needle in the hat *above* the wire, holding back a loop of cotton under the thumb. Stab the needle back again *under* the wire, bringing it through the loop from behind, and pull tight. Work from right to left. The stitches must just fit the wire [9]. Used for all parts requiring to be wired.

Gathering. Take up half as much on the needle as has been passed over [10]. Used when a long length has to be gathered into a very small space.

Shirring. Rows of fine gathering placed underneath one another. The stitches must exactly correspond with the row above, and the cottons are drawn up together [11]. This stitch is used for fancy linings for brims, for children's millinery, etc.

Tacking. A large running stitch [12]. Used for keeping two parts temporarily together.

Tacking for Crape. A long and small running stitch [13]. Crape being a springy material, this stitch keeps it better in position than ordinary tacking.

Basting. A long and a short stitch, the first taken slantways, the second perpendicular [14]. Used for holding together temporarily the material and lining previous to being tacked.

Lacing Stitch. Place the needle under the fold, and bring out in a slanting direction. Place the needle in again on opposite side, also in a slanting direction [15]. Used for securing the raw edges of velvet folds. It is sometimes called Milliner's Herringbone, but it differs from the ordinary herringboning by being always worked from right to left.

Catch Stitch. Take the needle under the turning and bring out to right side. Pass under the wire, then over the wire, and under the turning again, and repeat [16]. Used for fastening down the upper side of material brim to the second edge wire of under brim.

Round Bandeau Stitch. The stitches are taken close to the edges of the ribbon wire to prevent curling up. Make a long stitch of $\frac{3}{4}$ in. on upper edge of ribbon wire. Bring thread to bottom edge of wire at the back, take the needle through at nearly half the length of the upper stitch already made. Then take another $\frac{3}{4}$ in. stitch, and so on. On the reverse side a series of ∧ ∧ will be seen. Use black cotton on white net and wire, and vice versa [17]. Used for sewing ribbon wire to net for foundation of round and straight bandeaux.

Oversewing. Place needle pointing straight towards you in the raw edge, hold the work round first finger of left hand. Repeat this, forming a slanting stitch from right to left on the right side, and a straight one between each [18]. Used for joining lace, sewing fur, neatening the raw edges of velvet for straight bandeau where a turning will make a very clumsy and thick effect.

Whipping. The needle is taken over the raw edge of the material, put in from back to front, and over the edge again. The stitches are taken fairly long, and the needle, as for "fly-running," is not taken out until the finish [19]. Used instead of gathering, to prevent ravelling in lace or tulle.

Tie Stitch. Stab the needle through from the right side; leave an end of cotton, bring back the needle from the back, and tie a knot [20]. Used for securing light trimmings, trails of flowers, lace, tips of feathers, loops of ribbon on a brim; fastening head linings in position inside bonnets and hats.

Stab Stitch. Proceed as with the tie stitch, but take the needle through and through the hat for extra strength [21]. Used for sewing on trimmings that require more strength than the tie stitch gives.

ANTOINETTE MEELBOOM

Copper Ore and Its Treatment. Electrolytic Copper. Alloys of Copper. Brass and Bronze. Working of Brass and Bronze.

COPPER AND ITS ALLOYS

COPPER, the symbol of which is Cu, and the atomic weight 63·1, was one of the earliest metals discovered by man. The Copper Age followed the Stone Age, and preceded the Bronze Age. Copper weapons have been found in Egypt at a depth which, assuming the present rate of deposit as fairly constant since it was left there, gives its time of manufacture as not less than 10,000 years ago. The occurrence of large copper masses in the metallic state, the colour of which renders it easily recognisable, drew early attention to copper.

Physical Properties of Copper. The colour of copper is a characteristic red, with a tendency towards purple when cuprous oxide is present. It is only a little softer than nickel and iron, of the useful metals. Its tenacity and extensibility give it great industrial value: it can be rolled, beaten, and drawn into very fine leaf and wire. The specific gravity of the ordinary copper of commerce is from 8·2 to 8·5, rolled and hammered copper having a higher specific gravity than cast or crystalline copper. Electrolytic copper is 8·95. Roberts-Austen gives the specific gravity as 8·82. The precise melting point of copper has not been determined, but is between 1,050° and 1,100° C. Molten copper is of a sea-green colour, and of great fluidity. The thermal conductivity of copper is 736 (silver = 1,000) and the electrical conductivity 97·61 (Roberts-Austen) (silver = 100). Copper can be welded only with difficulty, and then only at a bright red heat.

Chemistry of Copper. Copper is unaffected by atmospheric exposure at ordinary temperatures, but under the influence of damp or of carbon dioxide it becomes coated with *verdigris*, an impure acetate of copper. When heated to redness in air it develops copper scale, a dark layer consisting of cupric oxide on top and cuprous oxide below.

Copper is immune from attack by water free from air, and by lime water, hence the value of copper for kettles and other utensils, for boilers and for boiler tubes. It dissolves easily in ordinary nitric acid and aqua regia, but only slowly in sulphuric and hydrochloric acids. It is remarkable, however, that the strongest nitric acid does not act on copper. Under an electric current copper may be separated from impurities and deposited on the cathode as pure copper, the application of this principle constituting the process of electrolytic copper refining, which we shall consider later on.

Sources of Copper. Within a half century the world's supply of copper has multiplied by ten, but the world's demands have grown quite as much as the supply, and the present high price of the metal is evidence that it is far from overtaking the demand. The main though not the only reason for this increase in consumption has been the growth of the electrical industries, with their huge demands upon the copper market. As the electrical industries grow and spread, so will the need for copper increase, so that there is no present likelihood of pause in an expanding consumption. The relative importance of the copper sources has undergone change during the last few decades. Formerly the world looked to Chili as the most important source of supply, but to-day the United States of America, with the enormous copper wealth of Montana and the Lake Superior district, supplies 60 per cent. of the world's copper requirements, with Spain a good second.

Copper Ores. Copper is found both in the native state and in combination. The largest deposits of native copper known are in the Lake Superior district of North America. New Mexico and South Australia also possess important deposits and the copper sand of Chili contains from 60 per cent. to 90 per cent. of metallic copper.

Copper pyrites, or *chalcopyrite* ($Cu_2S.Fe_2S_3$), known also as *yellow copper ore*, is the source of most of the copper supply of the world. It has a yellow colour with a black streak, a hardness of 3·5 to 4, and a density of 4·1 to 4·3. It is found at Rio Tinto, in Spain, and in every one of the five continents. Cornish ores, and the large deposits of Montana and Alabama, are of this variety.

Malachite ($CuCO_3.Cu(HO)_2$) is a beautiful streaked green copper ore which is much used for ornamental purposes. Its hardness is 3·5 to 4, and its density 3·7 to 4·1. It occurs in the Ural district of Russia, in Chili, and in Arizona and New Mexico. It contains, when pure, 57·33 per cent. of copper, but is seldom found pure, being usually associated with salts of lime and magnesia, oxides of iron and manganese and other substances.

Cuprite, or *red oxide of copper* (Cu_2O), is of a red colour with a red-brown streak, a hardness of 3·5 to 4, and a density of 5·7 to 6·0. It contains 88·8 per cent. of copper, and occurs in Montana in the upper sections of Butte City veins, in New Mexico, and in Russia.

Azurite ($2CuCO_3.Cu(HO)_2$) is of a beautiful blue colour with blue streaks, has a hardness of 3·5 to 4, and a density of 3·5 to 3·8. It is usually present with malachite, but in much smaller quantities. It carries 55·16 per cent. of copper.

Bornite, or *eburesate* ($3Cu_2S.Fe_2S_3$), or *purple copper ore* (sometimes also called *peacock* ore) is of a brilliant purplish brown colour when uncovered, but exposure to the atmosphere speedily causes it to change, and it may become yellow or deep blue, green or purple. Its copper content varies from 40 per cent. to 70 per cent. Its hardness is about 3, and its density about 5. It is found in Montana, Cornwall, and Chili.

Chalcocite, or *copper glance* (Cu_2S), is of a streaked dark grey colour, has a hardness of 2·5 to 3, and a density of 4·8 to 5·8. It usually holds at least 55 per cent. of copper, and the deposits in Montana carry from 60 to 74 per cent. It is also found in quantities in Arizona, Colorado, and New Mexico, while smaller deposits are found in many other places.

Treatment of Ores. The various ores of copper for metallurgical purposes may be classified into three groups. First there are the native copper ores, as found in the Lake Superior district, where the metal occurs in the form of metallic particles, and where the ore is concentrated mechanically, the resulting concentrate, or *mineral*, as it is termed, being melted down and toughened in refining

furnaces. Then the sulphide ores, the most important of which are copper pyrites, are subject to dry or wet processes, according to their nature and their copper contents. Dry methods are usually adopted with ores rich in copper and wet methods with poorer ores or with auriferous and argentiferous copper ores.

Chalcopyrite is a combination of copper with iron and sulphur, and the object in smelting is to separate the copper from these two and also, of course, to eliminate the gangue. The process depends upon the affinity of iron for oxygen and copper for sulphur. By calcination, or roasting the ores in heaps, or in shaft or reverberatory furnaces, they are freed from siliceous matter and concentrated, forming a copper *matte*, so-called. The matte is then smelted with a siliceous flux and oxide of copper is changed into a sulphide. Again it is fused with slag to oxidise the sulphide of iron and the result is a *white metal*, sometimes called *blue metal* or *fine metal*, with from 60 per cent. to 75 per cent. of copper. This is now melted in contact with air, and the oxide of copper formed reacts on the cuprous sulphide, forming an impure metallic copper (*blister* copper) and a slag rich in copper.

Copper Refining. The metal contains iron and other impurities, and has now to be refined. It is treated in a reverberatory furnace, and to remove the cuprous oxide poles of green wood are pushed into the bath, and charcoal or anthracite is sprinkled on the surface. When the metal has become pale and fibrous this refining is finished. The resulting copper ingot should show a flat surface. If it contain too much oxide it will be furrowed and is "underpoled," and if it be ridged on the surface it is "overpoled" and contains too little.

The modifications of this "reaction" process, as it is called, are numerous, and the varieties of furnaces and operations are very great. Each ore must be treated for its individual properties, and local conditions must also be considered. The "reduction" process is similar to the reaction process up to the "white metal" stage. The reduction process oxidises the sulphide completely, and reduces the mass by carbon. It is less economical than the other process.

The wet method of treating copper ore is followed for low grade ores. Copper sulphate is extracted from the roasted ore by bleaching with water, and the copper in solution is precipitated by the aid of another metal, usually iron, or by electrolysis. The great value of the wet process is that if the ore contain silver or gold these metals may be recovered.

Electrolytic Copper Refining. The electro-chemical treatment of copper ore has not yet been practised on a large scale, but electrolytic treatment of impure copper produces a copper of high purity, such as is required for electrical purposes. The principle of electrolytic refining of copper is simple. The electric current enters a bath of solution of sulphate of copper through an *anode* of impure copper and leaves it by a *cathode*. The action is that the anode is dissolved, but only the pure copper is deposited on the cathode, the remaining metals present as impurities, and also dissolved from the anode, not being so easily deposited as copper. We shall examine details of the process of electrolytic refining as practised in some of the largest works.

The first process in the electrolytic refining of copper is to melt the copper pigs or ingots so that they may be cast into the large flat plates which form the anodes in the electrolytic tanks. The charge of copper is melted in the *anode furnaces* as they are called, reverberatory furnaces used for this special purpose. Then the metal is worked by methods akin to those of puddling [see page 4635] for some hours, sometimes as many as thirteen or fourteen. This treatment dispels some of the impurities, and the copper is raised from usually 98·5 per cent. of purity to 99·5 of purity. Then the furnace is tapped, the metal is drawn off by the help of a ladle, and is poured into moulds which are mounted upon an endless chain. The copper plates which are to be used as anodes are 36 in. by 24 in. by 1 in. Each is made with two lugs on its upper edge, these being used to support the plate in the electrolytic tank. The plates are then put into frames holding 22 plates, the full charge for one electrolytic bath.

Electrolytic Bath. The tanks are filled with diluted sulphuric acid and sulphate of copper electrolyte, and are usually arranged in sets with a reservoir and pump to each set. They are arranged electrically in series, and the electrodes in each tank are parallel.

The thin cathode sheets used in the depositing tanks are themselves deposited in other tanks known as *stripping tanks*. The cathodes in the stripping tanks are pure rolled copper plates covered with grease or plumbago, upon the surface of which the new plates form, and from which they are afterwards easily detached. These new plates are beaten with wooden paddles and are hung by copper loops from copper rods which lie upon the edges of the depositing tank.

Now the electric current is passed through the bath, and the action is to transfer the copper of the anode plates to the cathode plates, upon which it is deposited. The charge is under treatment in the electrolyte for seven days, when the cathode plates have increased from 6 lb. to 8 lb. in weight to 75 lb. or 80 lb. Then they are removed and taken to the refining furnaces. The anodes, however, are not yet exhausted. New cathode plates are supplied and the process is resumed. The anodes last for six weeks.

The final process of refining is similar to that already described, when the green wood is plunged beneath the surface so as to remove the oxide by the carbon of the wood combining with the oxygen and escaping as carbon dioxide. The result of the process is a copper of 99·88 per cent. of purity.

Copper Castings. Casting copper so as to give good sound castings is not an easy matter, but it is a subject of some importance because several industries, particularly the electrical industry, are developing an increasing need for copper castings. The chief difficulties in casting copper are occasioned by impurities in the copper, by the formation of cuprous oxide while the metal is in a state of fusion, whereby blow-holes are caused, and by the great contraction during cooling, whereby the mould is not completely filled. The first-mentioned difficulty is overcome to some extent by the use of copper which has been electrolytically refined, and is therefore chemically pure. A common method of overcoming the cuprous oxide difficulty, in good practice, is by casting in chills or dry sand moulds, and by adding up to 5 per cent. of manganese at the time of casting. Manganese combines with the oxygen of the cuprous oxide, thus making the metal more uniform. Sometimes zinc or tin, up to 1½ per cent., is added, and has the desired effect. For very thin or very sharp copper castings, the introduction of one-half of 1 per cent. of phosphorus has beneficial effects. It has a deoxidising effect, and increases the fluidity.

Copper Oxides. Numerous compounds of copper have a place in industry. We cannot go into great detail in every one of them, but we can pass them under cursory review and indicate their value and importance.

Cuprous oxide (Cu_2O), otherwise known as *red oxide of copper*, *copper suboxide*, and *copper hemioxide*, is found in the native state as cuprite or red copper ore [see page 1718], and as chalcotrichite. It may be prepared by heating finely divided copper in air below red heat and in several other ways. It is used as a pigment, and, in combination with black oxide of copper, constitutes one of the copper antifouling paints used for ship bottoms. It is also used in the manufacture of ruby glass.

Black oxide of copper (CuO), or copper monoxide, is found as *melaconite* or *black* copper in native deposits, prominently in the Lake Superior district. It is used in organic analysis. It is also used in the manufacture of green and blue glass [see GLASS].

Hydrated copper oxide ($CuO \cdot H_2O$) is used in paper staining. It is of a blue colour, but develops into green under atmospheric exposure. Schweitzer's reagent, which is used in the manufacture of Willesden paper, is a solution of cupric hydrate in strong ammonia. Treated with this solution cellulose gelatinises and is completely solved. When the solution has been evaporated, a gummy mass consisting of cellulose and copper oxide remains. In making Willesden paper the solution is allowed to dry on the paper, making it water resisting and binding the constituent fibres together, thereby increasing the strength. Ropes and netting are also treated by the same process. Thorpe quotes the alleged best method of preparing hydrated copper oxide: "Six parts of copper sulphate are dissolved in water and mixed with a solution of three parts of calcium chloride. The clear liquid is decanted from the precipitated calcium sulphate and is mixed with one and a half parts of lime. made into a cream with water. The greenish precipitate is collected, washed and mixed with one-fourth of its weight of slaked lime and as much pearlash, and to render the colour more permanent one-fourth of its weight of ammonium chloride and one-half of its weight of copper sulphate are usually added."

Chloride and Other Copper Salts. The *Brunswick green* of commerce is *cuprous chloride* (Cu_2Cl_2). It has a wide use as a pigment. It is found native as *atacamite*. It is prepared from copper turnings by moistening them with hydrochloric acid or ammonium chloride under atmospheric exposure, or it may be made by boiling copper sulphate in solution with a small percentage of bleaching powder solution.

Cupric chloride ($CuCl_2$) is used for methyl violet in calico printing and for oxidising cutch colours. It is made by heating copper in excess of chlorine or by dissolving oxide of copper in hydrochloric acid.

Sulphate of copper ($CuSo_4 . 5H_2O$), or *blue vitriol*, as it is popularly known, is the most important salt of copper. It has many uses. In agriculture it is used for dressing wheat and other seeds. The practice is to soak the seeds in a weak solution of the salt within twenty-four hours of being sown. It is also applied to vines, usually as a solution of from 10 per cent. to 20 per cent. It is also applied to timber, and prevents rot. Sulphate of copper is also used in cotton printing, chiefly with potassium bichromate or iron mordants, and with logwood for black dyeing.

It is made from metallic copper, usually scrap copper, which is heated in a reverberatory furnace, sulphur being afterwards added and the doors shut. After some time the doors are opened and the heat is increased so as to oxidise the sulphide with sulphate. The hot mass is withdrawn, immersed in sulphuric acid (diluted), and, after settling, is decanted, concentrated and crystallised.

Cupric sulphide (CuS) is also used in calico printing for fixing aniline black. It is made in one way by precipitating a sulphate solution with sodium sulphide.

Nitrate of copper ($Cu(NO_3)_2$) has a limited use in cotton printing and textile dyeing. It is made by dissolving metallic copper or the carbonate or oxide in nitric acid.

Verdigris and Other Pigments. *Acetate of copper* is used as a pigment and in indigo dyeing as an oxidising agent. *Verdigris*, erroneously referred to by many authorities as a carbonate of copper, is a mixture of basic copper acetates, the monobasic, dibasic and tribasic acetates being present in different proportions in different varieties of verdigris. The varieties of verdigris are used for oil and water colour paints, for the manufacture of emerald green and other copper paints, and in dyeing and calico printing. Green verdigris is manufactured commercially by placing copper sheets for some weeks between cloths moistened from time to time with pyroligneous acid or acetic acid. The verdigris forms as green crystals. Blue verdigris is made by allowing the refuse of the wine press—consisting principally of grape skins—to ferment, and by placing into this thin copper sheets. The copper sheets become coated with verdigris. They are allowed to remain in the mixture for about two to three weeks, and are afterwards left to stand and subjected to occasional moistening with water or wine during some two months. The verdigris is removed and squeezed into cakes.

Emerald green, referred to above and known also as *imperial green* and *Schweinfurth green*, is an *aceto-arsenate of copper*. It is a brilliant green of pleasing shade and is largely used. Wallpaper stained with this green is found to give off a peculiar odour when the wall is damp, and this is alleged to be poisonous. This pigment is manufactured by mixing boiling concentrated solutions of copper acetate and arsenious oxide. The volume is doubled by the addition of cold water, and the mixture is placed in bottles or flasks filled to the top so that premature crystallisation may not occur. Crystallisation takes place gradually, and is not complete for a few days. There are other methods of making the pigment, but that described yields the finest product.

Scheele's green is arsenite of copper. It was formerly in extended use but is now of little importance. It is made by adding arsenious oxide to a boiling aqueous solution of potassium carbonate; after filtering, this is added to an aqueous solution of copper sulphate and the arsenite of copper is precipitated.

Some basic *carbonates of copper* are known commercially as *verditer* green or blue and *Bremen* green or blue. They are used chiefly for paper staining. *Malachite* is a basic carbonate. Verditer is made commercially by grinding sea salt and blue vitriol with water and digesting the resulting paste in wooden boxes along with pieces of copper plates. When the chemical action is complete, hydrochloric acid is added with agitation. Caustic soda and water follow as an addition to the mixture, and the product is washed, filtered and dried.

Alloys of Copper. The most valuable of the alloys of copper are those with tin and zinc, the tin-copper alloys forming the important family of the *bronzes*, and the zinc-copper alloys giving us *brass*, both of which we shall consider at some length. With gold and silver, aluminium, nickel, and antimony, copper also alloys well [see page 1323 and JEWELLERY], but with lead and iron it is unsatisfactory.

Successful alloys of copper depend greatly upon the absence of deleterious ingredients in the copper used. Cuprous oxide makes the metal red-short and cold-short, and the higher the proportion of cuprous oxide the more pronounced are these faults. It also causes castings of the metal with which it may be mixed to contract considerably. Sulphur in copper makes blown castings; silicon affects the ductility, pales the colour, and gives brittleness; nickel and antimony, singly or in combination, decrease the malleability; phosphorus increases the hardness and the fusibility.

Copper Alloyed with Gold and Silver. The British gold coinage is an alloy of gold and copper [see page 1189]. The colour of a gold-copper alloy shades into red, and green gold is an alloy of gold, silver, and copper. Silver-copper alloys are hard, strong, and tough, and give out a clear, penetrating sound when struck. Copper may be added to silver up to almost 50 per cent. of the alloy without changing the colour of the silver. Care must be taken in casting a silver-copper alloy, or "liquation"—that is, separation, may take place. In working articles of silver-copper, the frequent annealing necessary causes the copper to oxidise, giving the alloy a steel-grey colour. This colour is removed by the process of "blanching," so-called—that is, boiling the articles in dilute sulphuric acid (1 in 40). This process dissolves the surface copper and gives a surface of pure silver.

Bronze. Bronze is an alloy of copper and tin. It has been in use from prehistoric times, and in the early days it was more nearly a pure binary alloy than it became during the mediæval ages, when its value was usually impaired by a percentage of lead. Although tin is a soft metal by itself, it forms a very hard metal when alloyed with copper. If bronze is to be rolled into sheets, the percentage of tin must be small—not more than from 4 per cent. to 6 per cent.

Most of the bronze of commerce is not a mixture of pure copper and tin, especially when it is made with an admixture of old bronze, which usually contains oth r metals as impurities.

A small quantity of zinc in the alloy makes bronze castings sharp and tends to prevent blow-holes, but the zinc should not constitute more than 2 per cent. of the whole, or the appearance will tend towards that of brass. Lead in bronze is detrimental, especially when the alloy is to be cast; it increases the liability to oxidation, and as the lead tends to liquate from the bronze, the castings are unequal. Iron hardens bronze and gives a whitish colour; it is often introduced when the bronze is to be used for axle bearings. Nickel makes bronze harder, and decreases the toughness.

Properties of Bronze. The colour of bronze may be varied within wide limits by the different proportions of the constituent metals. Bronze with over 90 per cent. of copper is of a pure red colour. As the copper decreases, the colour passes through orange yellow to pure yellow at 85 per cent. of copper. A copper proportion between 50 per cent. and 35 per cent. gives a pure white bronze, and below this proportion the colour is steel grey, but as the copper becomes very low, the white colour reappears.

Tin reduces the ductility of bronze very much, and as low a percentage as 15 makes it impossible to hammer the alloy without fracture, even when it is hot. The maximum hardness of pure bronze is when it is made of 72·8 per cent. of copper and 27·2 per cent. of tin. As the tin increases above this proportion, the hardness diminishes, until, when the tin is two-thirds of the whole, the alloy is as soft as pure copper. Bronze, very rich in copper, is made very hard and very brittle by repeated forging. Cooling red-hot bronze rapidly makes it much less brittle and less dense, so that bronze bells rapidly cooled are deepened in tone. The higher the proportion of copper in bronze the higher is the point of fusion. Thus, bronze with 95 per cent. of copper melts at 2,520° F., while, when the copper is only 80 per cent., the melting point is only 1,868° F.

Bronze for Various Purposes. The general rules which should guide in the manufacture of bronze for various purposes have been given, but we may tabulate common formulæ of bronzes for various industrial purposes:

COMPOSITION OF BRONZES

Purpose.	Copper.	Tin.	Zinc.	Lead.
Rail waggon axles	75	20	2	
Piston rings	84	2·9	8·3	4·3
Stamped articles	64	5·5	30·5	
Small castings	94	6·0		
Cocks..	88	10	2	
Steam whistles	80	17	2	
Articles to be hard soldered ..	87	12	1 part antimony.	
To resist atmospheric action ..	93	7		
Speculum for telescopes	66·6	23·3		
Very tough	32	3	1	
Valves and fittings (Admiralty mixture)	90	10	2·5	
Soft gun metal	16	1		
Gun metal for casting	9	1		
Maximum hardness for bearing metal	5	1		
Bell metal..	4	1		
Ordnance metal	91·6	8·3		

For bronze statuary, the composition of the alloy depends upon the colour desired. The following proportions are recommended by Brannt to give the shades indicated:

COMPOSITION OF STATUE BRONZES

Colour.	Percentages.		
	Copper.	Tin.	Zinc.
Red yellow	84·42	4·30	11·28
Orange-red	83·05	3·92	13·03
Orange yellow	81	4	15
Pale orange	73	4	23
Pale yellow	70	3	27

Another authority states that the best statue bronze has the following composition: copper, 78·5 per cent.; tin, 2·9 per cent.; zinc, 17·2 per cent.; and lead, 1·4 per cent. If the proportion of zinc be too high in a statue bronze, the object loses the warm colour desired in statues, and when the zinc is too high the natural green tone, termed *genuine patina*, which a statue of the proper composition gains from exposure to the air, is not acquired, but one shading into black.

In making alloys into which tin enters, it is usual to put in one-half of 1 per cent. more tin than the final alloy is desired to carry, this quantity being lost by oxidation during the period of fusion.

Bell Metal. Bell metal is a variety of bronze, as it is essentially a copper-tin alloy. Occasionally, other metals are introduced in order to modify the tone. Common cheap bells are frequently made of brass or of steel. The low-priced bicycle bells are of this order, but gongs and house bells, clock bells, and sleigh bells, tower and church bells, are made from the bronze alloy known for centuries as bell metal. We refer under Manganese Bronze [see below] to claims for that alloy as a material for bells. It was formerly considered that a small percentage of silver improved the tone of a bell, but this view is no longer held, and the use of silver in bells is now discarded. The usual bell metal contains about 20 per cent. to 25 per cent. of tin. The following table gives the recognised formulæ for some bell metals.

COMPOSITION OF BELL METALS

	Copper.	Tin.	Zinc.	Silver.	Lead.	Bismuth
House bells	80	20				
Do. smaller ..	75	25				
Small hand bells ..	40	60				
French clock bells ..	72	26·56		1·44		
German do.	73	24·3	2·7			
Swiss do.	74·5	25			0·5	
Sleigh bells	84·5	15·4				
Gongs	82	18				
White table bells ..	17	80				3

A good bell metal is grey white in colour. In practice, the fracture determines the quality of the metal for the bell founder. If too coarse, the alloy must be made richer in tin; and if too fine, the tin is already too high, and copper must be added. Bells made from metals that have been frequently melted are not pure toned, this being caused by the oxide solution which has come into the alloy. But the art of the bell-founder embraces more than merely making a suitable alloy. The size, shape, and diameter of a bell, and the relation of its height to its diameter, have much to do with the sound that it gives out. Small bells are often cast in iron moulds, but large ones are always cast in the sand.

Phosphor Bronze. *Phosphor bronze* possesses very great strength, and can be rolled and hammered in a cold state. The name would indicate that it is a bronze carrying a certain percentage of phosphorus, but it is not always so. A more appropriate name would be *deoxidised bronze.* Phosphorus is used in the preparation of bronze, although the final metal may contain no phosphorus. Copper usually contains cuprous oxide in solution, and this oxide reduces the strength of any alloy made from copper containing it. By the introduction of phosphorus when the alloy is in a state of fusion, a complete reduction of the cuprous oxide is effected. The quantity of phosphorus can be gauged accurately in accordance with the cuprous oxide present in the metal. No phosphorus may remain in the alloy. A practice in making phosphor bronze is to introduce the phosphorus as phosphor copper or phosphor tin, or sometimes as both, these alloys having been prepared beforehand. To make phosphor copper heat four parts of superphosphate of lime, two parts of granulated copper, and one part of finely powdered coal in a crucible. Phosphor copper with 14 per cent. of copper will separate at the bottom of the crucible. Phosphor tin may be made by heating together three parts of anhydrous phosphoric acid, one part of carbon, and six parts of tin. Then, to make the phosphor bronze, 10 ounces to 12 ounces of this phosphor bronze or phosphor tin is added to each cwt. of molten bronze. The field of phosphor bronze is in articles such as hydraulic presses and propeller blades, where great strength is required. Sometimes lead or aluminium is introduced into phosphor bronze for specific purposes.

Silicon Bronze. *Silicon bronze,* which is an alloy of copper, tin, and silicon, or of copper and silicon only, has very high tensile strength, and has been much used for telegraph and telephone wires. Such wires have been erected with stretches of 1,000 ft. with no intermediate supports. Phosphor bronze has, however, largely taken its place. A formula recommended for silicon bronze specifies copper 97·12 per cent., tin 1·14 per cent., zinc 1·10; and silicon 0·05 per cent. The tensile strength of this alloy is said to be 600 lb. for 0·001 square inch section. Silicon bronze owes its properties to the fact that silicon, while reducing the cuprous oxide in the copper just as phosphorus does, seems to have a greater affinity for the copper than phosphorus has.

Manganese Bronze. *Manganese bronze* is, properly, not a bronze at all, but a brass; yet, on account of its name, we refer to it here. The following mixture is frequently used: copper 51 per cent., manganese copper (containing 20 per cent. of manganese and 8 per cent. of zinc) 40 per cent., and aluminium 1 per cent. The manganese copper, besides containing manganese, usually contains from 2 per cent. to 4 per cent. of iron. Manganese bronze possesses very high tensile strength. The alloy of the composition given above has a tensile strength of 36 tons per square inch and an elongation of 20 per cent. A higher percentage of zinc increases the hardness and tensile strength and diminishes the elongation, while a lower percentage has the opposite effect. The sphere of manganese bronze is in the manufacture of ordnance, propellers, pinions, and bearings, where its qualities make it desirable. As the tin constituent in the true bronze alloys is replaced by the cheaper zinc in manganese bronze, it is cheaper than the other special bronzes without showing inferior qualities as a special metal.

Manganese bronze finds some use as a bell metal instead of the usual copper and tin alloy generally used for the purpose. The advantages claimed by the advocates of manganese bronze for this purpose are that in comparison with the older composition it is more sonorous, has a mellower tone, and is not liable to be cracked. The usual bell metal is made very hard and brittle in order to improve the quality of the tone.

Aluminium Bronze. *Aluminium bronze* is an alloy of copper and aluminium, and contains no tin, hence the use of the word bronze is not quite accurate, although it has come to be accepted. The content in aluminium is never usefully higher than 10 per cent., but even up to this modest proportion colour and physical properties vary a good deal. With 5 per cent. of aluminium the colour is golden, at 7½ per cent. it partakes of a green-gold hue, and at 10 per cent. it is a bright golden colour. These alloys have great tensile strength, are exceedingly malleable in both the hot and the cold states, give sharp, clean castings, and admit a fine polish. The highest qualities of aluminium bronze are brought out by remelting it three or four times, and its strength may be further increased by hammering so that it may be made equal to steel. In casting aluminium bronze experience is necessary to good work. Its shrinkage is about twice as much as that of brass [see also page 1462].

Aluminium Brass. *Aluminium brass* is properly so termed, being an alloy of copper, zinc, and aluminium. Here also the percentage of aluminium is invariably low; if it be higher than 15 per cent. the alloy becomes red short and hard. An alloy containing 60 parts of copper, 30 parts of zinc, and 2 parts of aluminium can be worked mechanically by rolling, stamping, or forging, and has a valuable use for cartridge shells, because the aluminium imparts the property of resisting corrosion by the gases of the powder. It has been claimed that aluminium brass with from 1 per cent. to 3 per cent. of aluminium has much similar properties to aluminium bronze with from 5 per cent. to 10 per cent. of aluminium, and, of course, it is much the cheaper; but we question the evidence for this claim. Certainly aluminium brass is heavier and oxidises more easily. But the aluminium and zinc seem to form an intimate combination, and to develop properties even superior to the aluminium-copper alloys. The field for aluminium brass is in machinery parts and fittings in which exceptional strength is desired, such as valve seats, hydraulic and mining machinery, and propellers.

Bronze Powders. Most of the bronze powders used to coat metal, paper, wood, and other materials are made in Austria. A large number of different shades are procurable. Zinc and not tin is alloyed with copper to form the material from which they are made, so that the term *bronze* is technically incorrect. Powders which incline to white in colour have a high zinc content, and those that incline to red are high in copper.

Brannt gives the following compositions for some representative colours:

ALLOYS FOR BRONZE POWDERS

Colour.	Copper.	Zinc.	Iron.
Yellow	82·33	16·69	0·16
Pale green	84·32	15·02	0·63
Lemon	84·50	15·30	0·07
Copper red	99·90		
Orange	98·93	0·73	
Pale yellow	90·00	9·60	
Crimson	98·22	0·50	0·56

All the variety of shades are not, however, obtained by varying the composition of the alloy so much as by heating the alloy (after it has been finely pulverised), until a layer of oxide of the desired shade surrounds each individual particle.

In making the bronze powders the alloy is beaten into fine leaves by power hammers. These leaves are then forced through a fine sieve with the assistance of a scratch brush, oil being added at the same time, and the oil and powder passes through a grinding machine, which consists of one steel plate mounted with fine needles having blunt points revolving against another steel plate. The metal is here reduced to a very fine powder, and the oil is removed, first by putting the mass into water, where the oil floats off, and then by pressure.

Brass. Although the alloys of copper and tin—the bronzes—can claim antiquity, the alloys of copper and zinc, generally known as *brass*, can claim a much wider use industrially. Brass is properly a binary alloy, and should contain only copper and zinc; but pure brass is seldom made. The alloy is usually associated with tin, iron, lead and arsenic, those metals sometimes being present as impurities in one or both of the constituent metals, and sometimes again being added so as to modify the properties of the alloy. The two metals, copper and zinc, alloy within very wide limits. The higher the percentage of copper the more does the colour of the alloy tend towards gold, and copper also increases the softness and the malleability. As the proportion of zinc increases the colour becomes paler until it is a pale grey, and zinc increases the brittleness, hardness, and fusibility. A proportion of zinc up to 7 per cent. does not change the colour of the copper to an appreciable extent, but when the proportion comes above this quantity the tone is red-yellow. Then at 14 per cent. the colour has modified into pure yellow, and above 16 per cent. it goes into a mixed yellow, while at over 30 per cent. the red colour returns, and is at about its maximum when the two metals are present in equal proportion. As the zinc exceeds 50 per cent. the colour rapidly pales, passing through reddish white at 53 per cent., yellowish white at 56 per cent., bluish white at 64 per cent., and into lead colour as the zinc exceeds this limit.

Colours of Brass. The various phases through which the colour of brass passes as the proportions of the constituent metals vary may be given in the form of a table.

COLOURS OF BRASS

	Composition.	
	Copper. Per cent.	Zinc. Per cent.
Red	95	5
Reddish brown	90	10
Red-yellow ..	85	15
Reddish yellow	80	20
Light yellow ..	75	25
Yellow	70	30
Dark yellow ..	65	35
Reddish yellow	60	40
Golden yellow ..	50	50
Light grey ..	40	60
Lead grey	20	70
Darker lead grey	20	80
	10	90

The physical properties of brass, other than colour, are also much influenced by the proportions of the metals alloyed. A small proportion of zinc increases the fusibility without affecting the hardness; a high proportion increases the malleability when cold, but makes forging when hot impossible. Lead causes brittleness if it be present in brass in large quantities, but small quantities increase the ductility, making it better for turning and filing. A small proportion of phosphorus makes sounder brass castings, by increasing the fluidity and tenacity, and helps the alloy to resist atmospheric action. It also permits of tempering to some extent. The composition of commercial brass for many specific purposes is given in the following table [see also the table of bronzes which is given on page 1721].

COMPOSITION OF BRASS

Purpose.	Copper.	Zinc.	Tin.	Lead.
Gas fittings	40	20	..	1
Sheet brass for stamping and turning	3	1		
Brass wire	67	33		
Soft brass for hammering ..	7	3		
Tough brass for engine work	100	15	15	
Brass for soldering	8	3		
Sheathing brass	3	2		
Nails for sheathing	87	4	9	
Yellow brass	2	1		
White brass	10	80	10	
Red brass	16	2		
Brass for forging hot	33	25		
Pinchbeck	88	12		
Tombac	86	14		

The common quality of brass used in the foundry is termed in the trade *ash metal*. This is a general mixture suitable for cheap work, and is very wide in its quality. It is made by melting together scrap brass, borings and filings, sweepings and skimmings. These materials are riddled so as to free them from unnecessary dirt, and are washed, melted, and poured into ingots so as to be ready for use. Remelting improves brass, although there is loss of weight in any remelting, so that to remelt brass is more expensive than the mere cost of fuel and labour which it entails.

Standard yellow brass, so called, is an alloy containing two parts of copper to one part of brass. It is common to use this mixture already made as an ingredient in brass mixtures for casting, particularly for *red metal*, as it is called. A cheap red metal is made by alloying 36 parts of yellow brass (standard) with 46 parts of copper, 14 parts of lead, and 4 parts of tin. For highly polished red metal plumbers' fittings a common formula is 4 parts yellow brass, 16 parts copper, and one part each of lead and tin. For red metal to stand riveting the proportions of lead and of yellow brass are usually increased and the proportion of tin lowered. Thus, a good formula frequently followed takes 26 parts of yellow brass, 66 parts of copper, 5 parts of lead, and 3 parts of tin.

Brazing Metal. For the coppersmith the most commonly used alloy of copper is called *brazing metal*. Whatever may be the composition of the brazing metal—and this depends upon its purpose—it is always desired to retain to a great extent the malleability, fusibility, and colour of copper. If the zinc be higher than 20 per cent. of the alloy the red colour of copper is replaced by the yellow colour of brass. The chief use of brazing metal is in the manufacture of brass and other tubes. Brazing metal may be made from copper and zinc only, but very small additions of lead and tin make the alloy more easily worked in the sheet. A common mixture is eight parts of copper to from one to two parts of zinc. The best qualities have only 6 per cent. of zinc. Sometimes 2 per cent. of aluminium is incorporated, and is, indeed, specified in some Government work, but although tubes made to this formula give a more rigid joint than ordinary brazing metal, the aluminium makes the alloy less easy to work. A special article on engineers' coppersmithing is given in later pages in MECHANICAL ENGINEERING.

German Silver. German silver is brass with a proportion of nickel, the amount of which ranges from 15 per cent. to 25 per cent. according to the quality of the alloy. A formula frequently used prescribes three parts of copper to one part each of zinc and nickel. German silver ought to be of silver whiteness and almost untarnishable if made from pure metals, but the presence of impurities such as arsenic and antimony in the constituent metals detracts from this result. A small proportion of tin—up to 3 per cent.—permits German silver to take on a high polish; lead or manganese in a similar proportion increases the fluidity and gives good castings, while iron increases the hardness and helps the whiteness. The usual method of making German silver is to make an alloy of nickel and copper, and another alloy of nickel and zinc, the latter being added to the former while both are in the molten state [see also page 1323].

Copper Amalgam. Copper amalgam is an alloy of copper and mercury; it has a wide field of industrial use. Its chief sphere is in the recovery of gold from the crushed quartz by the use of amalgamated copper plates [see page 1184]. The alloy is not obtained by the direct method—that is, by uniting the fused metals. There are several methods of preparing copper amalgam, and we may notice one of them. Zinc strips are immersed in a sulphate of copper solution and shaken vigorously. The copper, which deposits as a fine powder, is washed and triturated with a solution of nitrate of mercury. Hot water is poured on the copper, and mercury (seven parts to three of the zinc) is added. The mass is kneaded into combination, and a longer kneading makes it more intimate. Then the water is discarded, and the paste remaining can be shaped to any desired form. Copper amalgam has the curious property of becoming soft when placed in boiling water. It is also used to a limited extent in cementing metals together. The metals to be joined must be heated to just under 200° F., after which the amalgam, usually in the shape of wire, is applied and the parts pressed together.

Manufacture of Brass. The earliest method of manufacturing brass was to fuse copper with zinc-bearing ores, usually calamine [see page 1588]. The results of this method were by no means uniform, owing to the varying properties of the ores used, even with ores from the same bed. Thus, as with all rule-of-thumb methods, the men who practised this method had to be expert in their judgment, able to tell by colour and fracture that the desired point in alloying had been reached. This method has not yet quite disappeared, but it has almost done so, and its death knell has long sounded in the best modern practice.

The present day practice of the brass-founder is to heat the metals in crucibles placed in furnaces. Many attempts have been made to dispense with the need for crucibles in brass making, but all attempts to fuse the metals direct in special furnaces have been unsatisfactory and have resulted in a return to the crucible. The types of furnace vary with the kind of fuel used, and with the size and regularity of the output. We may consider a furnace of small size heated with coke, and taking one crucible, capable of making about 80 lb. of brass. The furnace is about 28 in. deep with a horizontal section about 15 in. square. The chimney must be not less than 15 ft. high, and is usually 10 in. square, the flue connecting it with the furnace being, say, 7 in. by 10 in. The crucible rests on a firebrick placed on the firebars. It is heated, usually, by being placed upside down in the furnace. Then it is placed upright and packed around outside with coke. The copper and zinc have meantime been weighed in their proper proportions, but not mixed. The copper, in small pieces, is placed in the hot crucible and melted. Then the zinc, or spelter, broken into small pieces and warmed, is added gradually and stirred. Zinc volatilises, so that the proportion of zinc in the final alloy is never so high as it was in the weighed metal. Every time brass is remelted the zinc content becomes less. The brass-maker allows for this loss by using more zinc, in a definite proportion, than he wishes the alloy to show. As the metals fuse, the surface is sprinkled with powdered charcoal, borax, or broken glass, so as to prevent oxidation. After all the zinc has been melted the crucible is covered over for a few minutes before being poured. If part of the charge is old brass, this is melted first, then the copper is added, and when the latter is fused the zinc is put in as already described.

Brass Furnaces. There are many so-called improved furnaces, each with specific claims to merit, offered for the use of brass founders, but the

common furnace has too strong a hold to be easily displaced. Tendencies during recent years have been towards liquid fuel instead of hard coke, and the value of many patent furnaces offered has consisted in their ability to utilise cheap oils as fuel. Gas is also used for brass melting, and may be the most economical fuel with a very small plant and where the work is intermittent.

Patterns for Brass Castings. Patterns are discussed at length in articles on Patterns and Castings under MECHANICAL ENGINEERING, and reference should be made there for general instructions. The small size of most brass castings causes the use of metal patterns to a far greater extent than for iron castings. Metal patterns, generally, give cleaner castings than wood patterns, and brass castings often carry some finely cut ornamentation for which wood would be unsuitable as a material upon which to work. Metal patterns for brasswork are usually made of brass, primarily because it is more convenient to make them of brass in a brass foundry, and also because brass patterns require no preliminary preparation, such as rusting and varnishing, as iron patterns do, an application of a black-lead brush being all the treatment required.

Moulds for Casting Brass. The condition of the sand is of great importance in brass casting. If the moulds are made of loam they must be thoroughly dried before use. Good moulding sand is better than loam, however. If the sand is too meagre it will give a rough surface, occasioning labour and expense in finishing. The addition of a little flour paste to the sand will obviate this trouble, and if the sand be too "fat," the addition of powdered charcoal will prevent bad effects. The pouring temperature must be carefully gauged. If the metal is not hot enough, sharp castings cannot be secured; and if it is too hot, porous castings will result, and there will be loss of zinc by oxidation. Casting from the bottom is desirable, as the air cannot rise through the casting and cause blow-holes.

Brass-founding. In brass-founding, the ordinary iron-founding practice is generally followed, but there are a few points where variation is required. The contraction of brass in cooling is greater than that of iron, therefore the patterns have to bear a different relation to the work. Small castings of brass—say, under 12 in. long—shrink $\frac{1}{8}$ in. in each foot, and over this size the contraction is $\frac{3}{16}$ in. Brass sets more quickly than iron, therefore the molten metal must reach home more quickly, and to secure this the gates and runners are usually made larger. The sand used for brass is generally more porous than it is for iron, and there is not so much venting. Much brasswork is poured through the ends of the mould boxes instead of by the top, the boxes in the end pouring being made to be at an angle in a trough, the object being that spilt metal may be recovered from the trough instead of being lost in the sand. Vertical pouring, which is common with iron castings, is infrequent with brass, there being no risk of scabbing and of blow-holes in the latter case.

Casting Bronze on to Iron. Sometimes it is desirable that a piece of mechanism should be of iron or steel inside and of brass or bronze outside. We may take as a typical instance of such work the pump plunger, which may be wanted with an iron or steel centre and with the working part of bronze which will withstand corrosion. The bronze part could be cast separately and fitted on, but this method entails much labour and expense. A cheaper and thoroughly satisfactory job may be made by casting the bronze upon the iron as a centre if proper precautions be taken. Brass or bronze cast upon iron is more or less spongy or porous, and would, in most cases, be unsatisfactory as the working surface of a piece of mechanism. The method of overcoming this objection is by casting upon the iron or steel a layer or brass or bronze only half of the desired ultimate thickness of the brass or bronze. The centre, of iron and steel, should for preference be tinned, as the copper alloy will unite with the tin easily, but tinning is not essential. Its absence may cause a little spluttering as the metal is poured, but it will give as good a result as when tinning is practised. If the iron or steel be not tinned, it should be cleaned and polished. In casting, this iron or steel is used as a core, and the porous coating of brass or bronze forms a good surface upon which to cast a second and final layer of brass or bronze, which will not in this case have the tendency to be spongy. The second pouring is made when the first cast is cold and when, of course, the second mould has been prepared for it. The second cast should be given under a good head of metal so as to get a good dense casting. The two castings of brass or bronze should unite solid, and can be machined in the usual way for the finished mechanism.

Modelling. In brass castings, especially those of an ornamental nature, modelling in clay is practised in the preparation of patterns to a considerable extent. The clay model is reproduced in plaster of Paris, and from the latter tin sections are cast, or rather sections made with an alloy of three parts of lead to one part of tin. These sections, when built up together, form the working pattern for the moulder. Modelling is used in ornamental ironwork also, but we give it an extended notice in this section on account of its application in the brass foundry and because most textbooks neglect it.

Modelling is chiefly suitable for light and ornamental castings. The actual task of modelling in clay is the work where, more than in any other which falls to his lot, the workman may give expression to any artistic feeling he may possess. The general work of clay modelling is fully discussed in another course [see SCULPTURE in Group 3], and the technical details there given permit us to be brief upon that part of the subject. The clay must be soft and pliable. It is prepared by grinding, and all stones and grit are removed. The tools necessary are few and simple. The most important are the ten fingers of the workman, and he supplements these by a few boxwood modelling tools and floats. The chief work is done with the fingers, which press and knead the clay into the form desired. The tools are used to impart the finer lines, to remove any excess of material, and generally to give the finshing touches. The work is nearly always in low relief, as high relief would be impossible without undercutting, which would not allow the article to leave the mould.

The work is usually done on a modelling board, stiffened at the back and coated on its surface with a few applications of shellac varnish. Thus the moisture of the clay does not penetrate into the board. This board is placed on trestles or on a bench, and the clay is placed on it and manipulated as already stated, the operator working to his drawing. If the work cannot be completed at one sitting, a damp cloth thrown over the clay will cause it to remain soft and pliable. The work finished, the clay is allowed to get somewhat firm,

after which it is removed from the board, which may be helped by pulling a piece of thin wire right down the board, meantime holding it across the full width of the board under the clay. If the impression of the clay model is to be taken in plaster of Paris, this is generally done before the clay leaves the board. The tin alloy pattern is cast from the clay on the plaster of Paris counterpart in the ordinary way, and the material, while hard enough for ordinary handling, is pliable enough to be bent and modified in shape and to have the ornamentation cut or deepened with ease and good result.

Brass Burning. In casting brass, it may be that the casting desired is too large for the capacity of the crucibles or of the furnace. The difficulty is overcome by *burning* or autogenous soldering [see following article]. The process consists in making the full-sized casting in two or more pieces; then, by placing these in their proper positions in a sand mould and by pouring molten brass so that it flows around the surfaces it is desired to join, a homogeneous casting as strong as if it had been cast in one piece is obtained. In preparing the brass castings for burning, the surfaces where the join is to take place are filed or scraped, so as to free them from scale. It is desirable that the new metal should be hot, therefore an excess of metal is allowed, the first part of the pouring flowing out through a gate and heating the surfaces as they pass over them; then the metal that remains finally comes upon the heated surfaces and the union is made.

Plate Brass. Brass which has to be subsequently rolled into sheets or cut into strips to be drawn into wire [see WIREWORK] must retain its ductility, hence special precautions are necessary in casting the thin plates which are to be subject to this special treatment. Sometimes iron moulds have been tried, but have never had extended favour due to the fact that the brass cools off too rapidly, although this defect might be overcome by heating the moulds before casting, and by allowing them to cool off gradually by the application of external heat.

In many places loam moulds and sand moulds are used, but granite moulds are also in extended use, and give good results if properly manipulated. A granite mould is made of two granite slabs, the lower one a little wider than the upper. Both have an even coating of clay covered with cow dung, and are kept at the proper distance apart by iron bars placed between them at their ends. The slabs are bound together with iron bands. Their normal position for pouring is at an angle of 45° from the horizontal, and as soon as the poured plate has solidified, it is removed and another poured, so that the mould remains warm. The plates removed from the mould are cleaned with wire brushes. Then they are rolled and sometimes hammered. Sometimes they are rolled hot only, and sometimes the hot rolling is finished by cold rolling. This depends upon the nature of the brass. The composition may be capable of extension by rolling only if hot. Between each rolling the sheets are annealed to give back the ductility which the previous rolling has taken from them, and before passing between the rolls they are coated with oil. If the final sheet be required soft, the last process is one of heating and quenching in water, while if a hard sheet be required, this heating is omitted.

The sheet at this stage does not resemble brass. It is black, and must be pickled—that is, dipped into a bath made of water with 10 per cent. of sulphuric acid. This may complete the preparation for the market, or another bath of nitric acid in water or a mixture of nitric and sulphuric acids in water may be given. Nitric acid dissolves zinc more quickly than it dissolves copper, so that a sheet that has come from a nitric acid bath has a surface richer in copper than the body of the sheet; hence a redder shade of brass.

Casting Bronze Statues. France is the headquarters of statue-founding in bronze. In that country the appliances and methods are the best, and the results unexcelled, and seldom equalled. The old process of statue-founding was by what is known as the *cire perdu* process [see BRONZE CASTING IN ARTS], and this is still practised. By this process a rough model of the object is first made in sand or porous cement, and this is coated with wax to the same thickness as the metal which is to form the statue. Then the artist works upon this wax surface, giving the final form by delicate touches. Then several pieces of wire are pushed through the wax into the core. Now the wax is carefully coated with liquid sand, and is placed in an iron frame, which is filled up with sand. The frame is taken to a warm place, where the moisture escapes from the sand, which becomes firm. Holes are now pierced through to the wax coating, and the frame is then placed in a hot oven, where the wax melts and runs out, leaving the core supported in position by the wires which were inserted for the purpose. Bronze is now poured in by the holes through which the wax escaped, and the statue is cast. If this process produce a perfect statue, all is well, but this result is by no means certain. The operation is delicate, flaws are frequent, and if the statue be imperfect, the work of the artist has gone for nothing, because his wax model has been destroyed in the process. For this reason the *cire perdu* process has been superseded in the best French practice by a less risky process, which leaves the work of the artist uninjured if the casting be bad, so that subsequent attempts may be made without the necessity of beginning the work again *de novo*.

Piece Moulding. By this newer method the sculptor makes his design in plaster, and the rest of the work is mechanical, albeit demanding a high degree of skill on the part of the founder. The plaster statue is placed in a bed of sand, so that it may rest solid and still be comparatively safe from injury. Then the moulder begins the operation of *piece moulding*, so-called. Selecting a small section of the statue, he presses sand into every crevice in it, and obtains thereby a mould giving an exact impression of that section to which he has been devoting attention. He does the same with another section of the statue, and so on until he has the whole surface of the plaster statue impressed upon the several moulds that he has made. The plaster statue itself may now be put aside, and may not again be required. The small impressions that have been taken in sand are carefully fitted together in their proper places in the mould-box—a task requiring high skill. A rough facsimile is now made, a little smaller than the original statue, and this does duty as a core, the space between the two faces representing the thickness of metal of which the statue is to be. The mould and core are then dried in an oven to remove moisture, and to harden the sand. Vents and runners are made, and when all is ready the casting is poured. Should it be faulty for any reason the operation must be repeated; but this is not the serious matter it is by the *cire perdu* process, because the plaster statue remains upon which to work.

In statue-founding great care is taken in selecting the metal. Colour and homogeneity depend upon the bronze alloy, and no metal of which the exact composition is not known is allowed to enter. No old brass and copper are used, and the ingot copper employed is usually purified by liquidation before the actual process of founding. Good work is possible only by having a highly finished mould capable of producing a sharp casting which will require only very little chasing. The sand employed is also important. It must be carefully selected; it is usually blended to suit the nature of the work in hand, and is then passed between cast-iron rollers to give it uniformity. The moulding boxes must be accurately fitted, and their edges are usually planed.

Dressing Castings. Castings which come from the mould must be *dressed* or *fettled* before being ready for the more delicate operations of finishing. The nature of the dressing depends upon the metal under consideration, the perfection or, rather, imperfection of the casting, and upon the subsequent finishing processes, if any, to which it is going to be made subject. The processes of dressing castings are similar whatever metal may be employed, and we shall describe briefly the appliances used, having special regard to the fact that we are considering castings of brass and bronze.

The usual extraneous metal upon a casting as it emerges from the sand takes the form of ragged edges, fins and spurs. Cores are removed from castings usually in the foundry, and if they be large this is usually done before the casting is quite cold. A casting is *trimmed*, the first process entailing the removal of prominent spurs, by being *chipped*, by the hammer only, or, if necessary, with the assistance of a cold chisel. Sometimes pneumatic hammers [see MACHINE TOOLS] are used. Then fins, which are not sufficiently prominent to be properly removed by this means, are rubbed, generally with old files, which have served their first usefulness in the fitting or machine shop. Sometimes cast-iron files are used. For brass there are not the same reasons of economy for the use of old files, and good files may be employed, the brass being softer. Then the castings are usually ground. Grindstones used to be employed, but the better practice is to use emery wheels [see MACHINE TOOLS]. They are better than grindstones. They should not be "forced"—that is, the work should not be pressed against them with too great force, as this is bad for both the work and the tool. For large castings, which cannot be moved about over the periphery of the wheel, an emery wheel fitted to the end of a flexible driving shaft may be used. It can be applied to any accessible part of a stationary casting, but brass castings are seldom of so large size as to demand treatment by this method. But a wire brush mounted upon a flexible shaft in this manner is often used, and is valuable as an instrument for removing adhering sand.

Dressing by Sand-blasting. Another process often employed for small castings is that of "rumbling"—that is, placing them in a cylindrical chamber which is made to revolve upon a horizontal axis. As this process wears the edges chiefly, it is not suitable for small castings of an ornamental nature. A similar process is employed in pin manufacture, and also in tinning. Sharp sand, small star-shaped castings, known as "stars," and sometimes sawdust are placed inside the rumbling cylinders, and made to revolve with the castings under treatment. But perhaps the best method of cleaning cast surfaces is by a sand-blast machine. This ingenious invention—similar to that used for decorating glass [see GLASS]—is a vessel in which a supply of sand is contained in a chamber with an aperture at the bottom, this aperture being capable of regulation as to size, and as a thin stream of sand falls through the aperture it encounters an air blast—usually from 5 lb. to 15 lb. per square inch—which carries it through a flexible tube to a nozzle, whence it is blown upon the surface of the casting. The workman guides the nozzle, and its value over the tumbling process already described is that the work can be directed to the points where it is most required, and not to prominent points only.

Brass Spinning. The die press and the draw press have modified the practice of working sheet metals considerably, not only by doing away with the need for much of the hand or "piece" work formerly undertaken, but also by making possible many forms of work formerly unattainable. The process of spinning sheet-metal is usually subsequent to the work of the press, which is an economical means of securing a blank suitable for spinning. Spinning is an operation whereby an object such as a reeded curtain-pole end, a brass bed-knob, or a berry pan is given its shape. The operation is simple, but clever. It can be carried out upon work in the flat state which has been cut out by hand or by press, but it is economical in most cases to put the work through the draw press before spinning. For spinning, a "former" is required. This former must be of the shape which it is desired the final form of the article shall have. The widest part of the former must never be larger than the narrowest neck of the spun article, else the former could not be withdrawn after the article had been spun.

The Spinning Lathe. The lathe, in which the work is performed, is a machine with a bed and fixed headstock having a chucking arrangement suitable for holding the articles, usually of cylindrical or cup shape, or something approaching thereto. The article is held in position on the formers by a movable tail stock, and special burnishing or friction rollers carried upon a compound slide-rest are made to press against the work, and cause the metal to "flow" into the required shape, the form being given by applying the pressure at the proper points. It is possible to give by spinning not only plain ridges and grooves but ornamental patterns, such as milled, beaded, and spiral edges, such forms being attainable by the use of pressing rollers and formers carrying the particular pattern it is desired to impress upon the work. For spinning work, the result depends upon the high speed at which the work is made to revolve. The operation we have described utilises burnishing or friction rollers attached to the slide-rest. This is the modern practice, and is the best for cheap work where thousands of one article are being made; but for some work other than brass, such as spun Sheffield ware, it is common to use burnishers, held by hand and pressed against the work without mechanical aid other than the strength of the workman.

Spinning is possible by reason of the malleability of the material employed. The effect is to cause hardening just as in the operations of drawing and raising metals, and therefore annealing is necessary when the work of spinning is of a prolonged character. Besides the brasses, Britannia metal is used, and in a lesser degree zinc and aluminium. The "forms" or chucks are of hard wood usually, attached to the mandrel nose. Only when large numbers of similar pieces are required are forms of metal employed.

Articles of Partnership. Interest and Division of Profits. Admission of Partner. Dissolution of Firm. Division of Ledger. Balancing by Sections.

PARTNERSHIP ACCOUNTS

Use has been made in the preceding pages of the words "partners" and "firm," but the general question of partnership has not hitherto been considered. Sir Frederick Pollock, in his work on the subject, defines partnership as "the relation which subsists between persons who have agreed to share the profits of a business carried on by all or any of them on behalf of all of them," and it is difficult to imagine a more comprehensive definition in few words. The legal relations between partners and the outside world are defined by the Partnership Act, 1890, which codified the law on the subject, and that statute contains the regulations under which partnerships are carried on in the absence of any special agreements between the members of a firm. It is usual, however, in practice for a formal agreement defining their rights and liabilities to be drawn up and executed by partners in a business.

Articles of Partnership. This document is entitled "The Articles of Partnership," and deals, amongst other matters, with the amount of capital to be contributed by each partner, the limit up to which each may draw money from the business on account of his share of the profits, the way profits and losses are to be divided, the question whether interest is to be allowed on the capital introduced or charged on the amounts withdrawn, and the method of arriving at a partner's share of the property in the event of dissolution of the partnership. The manner in which these matters are dealt with varies in different firms, and is a matter which concerns the partners only.

The principal points of difference between the accounts of single traders and partnership are three in number:

1. Each partner has a separate capital account, which is divided into (*a*) capital account; and (*b*) drawings account;
2. Interest on drawings and capital;
3. Division of profits and losses.

There is no hard and fast rule for any of these matters; they are the subject of agreement between the partners themselves.

Separate Capital Accounts. A separate account for each partner is absolutely necessary, as each individual member of a firm is entitled to his own share of the partnership property and no more. The amounts contributed by the partners are in the majority of cases unequal, and it would clearly be inequitable to amalgamate the capitals and give each partner equal rights irrespective of the amount he had brought in or of the work he was to perform. The sum contributed by each partner is therefore debited to cash and credited to him on a separate capital account opened in his name. If a partner should bring into the business any property other than cash, an account is opened and debited with such property, the partner being credited with the value as agreed with the other members of the firm.

It is expedient also to have a separate account for recording the drawings of the partners from the business. The amounts drawn may be numerous, and it is very undesirable to have a large number of small items of cash and goods debited to the capital account proper. As already explained, when a partner draws cash on account of his share of the profits he is debited with the amount, cash being credited. At the end of the financial year, when the accounts are balanced, his share of the profits is ascertained in accordance with the provisions of the partnership articles, and he is credited on his drawing account with the amount. The excess of his share over his drawings is then transferred to the credit of his capital account.

Interest on Capital and Drawings. The question of interest is one entirely within the discretion of the partners when settling the terms of the partnership. In the absence of any arrangement to the contrary interest is not allowed, and it is therefore usual, where capitals are unequal and profits are not shared in proportion to the respective capitals, to stipulate that interest at an agreed rate, usually five per cent., shall be charged to the business for the use of the money and credited to each partner according to the amount of his capital. On the other hand, it is frequently arranged that interest shall be charged against the partners on their drawings, this, of course, forming a credit to the business. The entries necessary to record these charges are (1) a debit to the profit and loss account and a credit to each partner on his drawings account of the amount of the interest on his capital, and (2) a debit to each drawing account and a credit to profit and loss of the amount of the interest on the drawings, this being calculated from the dates on which the drawings take place to the date up to which the accounts are prepared. It may be pointed out that when profits are divided in proportion to the partners' capitals there is no object in charging interest on capital, as the net result will be the same as if no charge were made.

Division of Profits. The manner in which the profits and losses of the business are to be shared depends, as a rule, upon two things: firstly, the amount of each partner's capital; secondly, upon the share which each

takes in the management of the concern. It sometimes happens that a considerably greater amount of work is done by one partner than by another, and this is equalised by the working partner being allowed either a partner's salary or else a larger share of the profits than he would be entitled to having regard to the amount of his capital.

In order to show clearly the working of the drawings and capital accounts a specific case will be considered. Grey and Green are partners with capitals of £3,000 and £1,000 respectively. The business is managed by Green, for which he is allowed a salary of £200 per annum. Profits are shared in proportion to their capitals, interest at 5 per cent. being allowed on the latter and charged at the same rate on drawings. Grey's drawings were £50 on 31st March, £75 on 30th June, and £40 on 30th September. Green's only drawing, with the exception of his salary, which he received quarterly, was £30 on 30th June. The profits of the business, after charging and allowing interest in the profit and loss account, was £600. [See Tables below.]

In preparing the balance-sheet of a firm it is usual to show the capital accounts of the partners in detail. The capital accounts of Grey and Green would therefore appear in their balance-sheet.

LIABILITIES		
Sundry Creditors, viz. :		
On Bills Payable	685 7 0	
On Open Accounts	1,819 15 6	2,505 2 6
Capital Accounts :		
Grey balance, Jan. 1st	3,000 0 0	
Add Interest	150 0 0	
Share of Profits	450 0 0	
	3,600 0 0	
Less Drawings and Interest ..	169 5 0	3,430 15 0
Green balance, Jan. 1st ..	1,000 0 0	
Add Interest	50 0 0	
Share of Profits	150 0 0	
	1,200 0 0	
Less Drawings and Interest ..	30 15 0	1,169 5 0
		£7,105 2 6

Admission of a Partner. From a variety of causes, such as retirement of a partner, increased business, or want of further capital, a new partner is frequently introduced to a firm. The terms upon which he is admited are matters for arrangement, and usually include the investment by him of a fixed sum in the business and

Dr. GREY'S DRAWINGS ACCOUNT Cr.

Mar. 31	To Cash	50 0 0	Dec. 31	By Interest on Capital ..	150 0 0
June 30	,, Cash	75 0 0	,,	,, Profit and Loss Account, being ¾ of profits	450 0 0
Sept. 30	,, Cash	40 0 0			
Dec. 31	,, Interest on Drawings	4 5 0			
,,	,, Transfer to Capital a/c	430 15 0			
		£600 0 0			£600 0 0

Dr. GREY'S CAPITAL ACCOUNT Cr.

			Jan. 1	By Cash	3,000 0 0
			Dec. 31	,, Transfer from Drawings Account ..	430 15 0

Dr. GREEN'S DRAWINGS ACCOUNT Cr.

Mar. 31	To Cash	50 0 0	Dec. 31	By Salary as Managing Partner	200 0 0
June 30	,, Cash	80 0 0	,,	,, Interest on Capital ..	50 0 0
Sept. 30	,, Cash	50 0 0	,,	,, Share of Profit	150 0 0
Dec. 31	,, Cash	50 0 0			
,,	,, Interest on £30 drawings	15 0			
,,	,, Transfer to Capital a/c	169 5 0			
		£400 0 0			£400 0 0

Dr. GREEN'S CAPITAL ACCOUNT Cr.

			Jan. 1	By Cash	1,000 0 0
			Dec. 31	,, Transfer from Drawings Account ..	169 5 0

the payment of a premium to the existing partners. The premium is usually regarded as being in respect of the goodwill of the business, and as it frequently happens that there is no account in the books representing that asset, and it has not been necessary hitherto to arrive at the value of it, the price to be paid in this respect is generally fixed upon the basis of so many years' purchase of the annual profits. Two years' purchase is a very usual price, but it may, of course, be either more or less according to the nature of the business.

The premium may be dealt with in two or three different ways. The cash the new partner introduces as his capital will be debited to cash and credited to his capital account. The premium may perhaps be paid to the old partners direct and not come into the new firm's books at all, or it may be paid into the firm's bank account and credited to the old partners in such proportion as may be agreed between them. It is sometimes arranged that instead of a payment being made by the incoming partner a goodwill account is opened and debited with an agreed amount which is credited to the partners in proportion to their shares in the business.

Dissolution of Partnership. In the absence of any agreement to the contrary, a partnership is indefinite as to its duration, but it is automatically dissolved upon the happening of certain events, two of which are the death or bankruptcy of a partner. It is not unusual for the articles of partnership to provide that upon the death of a partner his share in the business is to be calculated upon a certain basis in order to avoid the necessity of preparing a balance-sheet in the middle of a trading period. One method is to take his capital as at the date of the last balance-sheet and allow the addition of profits at the rate of the average for the three preceding years, providing also for the valuation of the goodwill. It is sometimes further provided, in order that the business shall not be crippled by the sudden withdrawal of a large amount of capital, that payment to a deceased partner's representative shall be made by instalments. In other cases provision is made for such a contingency by an insurance of the lives of the partners being effected at the cost of the firm, which will, of course, receive the sum insured in the event of the death and use the money to pay out the deceased partner's capital.

Final Winding-up. The kind of dissolution, however, which requires further explanation is the complete winding-up of the firm owing either to failure or to the period for which it was entered into having terminated, or to general agreement amongst the partners to discontinue business. In any of these events it is necessary to realise the assets and pay to each partner the amount due to him in respect of his capital. The first step to be taken is to prepare a balance-sheet as at the date of dissolution. An account called the realisation account is then created, and the values of the assets as appearing in the books are transferred to its debit, the various assets accounts being closed by being credited by the amounts so transferred. As the realisation proceeds, cash account will be debited, and the realisation account credited with the sums received.

When the assets are sold the balance of the realisation account will represent the gain or loss on realisation, probably the latter, for assets seldom realise their book values. This balance must be treated in the same manner as if it were the balance of the profit and loss account. If it represents a gain, it will be transferred to the credit of the partners and increase the amount of their capitals, while, on the other hand, if, as is probable, there is a loss, it will be transferred to the debit of the partners and reduce their capitals. Any expenses of realisation will also be debited to the realisation account as they are paid, while cash will be credited with the payments as well as with payments to the creditors. The result will be a balance on the cash account representing the excess of the proceeds of the sale of the assets over the liabilities and the expenses of winding up. As all the assets have been sold and their proceeds received in cash, the balance of the cash account will equal the aggregate of the balances on the partners' capital accounts after the latter have been debited with the loss or credited with the gain on realisation.

Self-balancing Ledgers. We have so far assumed that one ledger only has been used in the businesses with which we have dealt, but it will have been obvious to the observant reader that in undertakings where a large business is carried on the debtors and creditors must be too numerous to allow of all their accounts being kept in one book. Where this is the case, it is necessary to divide the ledger into sections, each set apart for a particular class of transactions. It must be remembered that where separate books are used the ledger as a whole consists of all the different sections, and if it is desired to prove the books at any time by means of a trial balance, it will be necessary to extract the balances of all the accounts in every ledger before agreement can be obtained.

This, in a business where there are hundreds of debtors—and there are many such—is a work of considerable magnitude; and if when all the balances have been extracted the totals do not agree, the bookkeeper is at a loss to know in which ledger to look for the error. In order to obviate the necessity of searching through all the ledgers to find a difference which may exist in only one of them, a method has been devised by which it is possible to localise errors and thus restrict the search to the particular section indicated as being that in which the error has arisen. The system is variously known as sectional balancing, self-balancing ledgers, and balancing by totals, but, subject to very slight modifications, these terms refer to the same system whichever name is employed.

Sectional Principle. The underlying principle is that each ledger must contain *in itself* a complete double entry of all the transactions recorded in it. This is, of course, always the case where only one ledger is used, but when,

owing to the increase in the number of accounts, it becomes necessary to have more than one ledger, it is highly probable that while the debit side of a transaction may be posted to one ledger the credit side will be posted to another. Thus, in the case of a sale of goods the debit to the customer would be made in the sold ledger, while the credit to the goods or sales account would be made in the general ledger. If nothing further were done, it would be necessary, in order to obtain a trial balance, to extract the balances of all the ledgers, but if each ledger is so arranged that the total of its debits is equal to the total of its credits, it will be possible at any time to extract a trial balance of each ledger separately, and so ascertain that the work of posting has been correctly performed. This may sound somewhat like duplicating work, but it is not so in fact, and the gain is so enormous in a large concern that the slight amount of extra trouble is fully compensated for by the result achieved.

The system is only necessary in a business where the ledger is divided. The first division which is made is usually into (1) sold ledger, containing the accounts of the debtors; (2) bought ledger, containing the creditors' accounts, and (3) general ledger, set apart for such accounts as stock, purchases, sales, the various revenue and expenditure accounts, the capital and drawings accounts of the partners, and the assets of the concern, other than book debts. The sold ledger is frequently further divided into sections set apart for town and country debtors, or for portions of the alphabet, and sometimes for both.

Separate Sold Ledgers. It will be sufficient for the purpose of explaining the system to take a case where the sold ledger is divided into town and country ledgers, as the principle applied is the same whatever the number of ledgers. There must be either separate books of first entry for each ledger (and this is the better method where the ledgers are numerous), or the books from which the ledgers are posted—*viz.*, the sales, returns inward, cash and bills receivable books—must be ruled with columns for both ledgers, care being taken to enter the items in the column relating to the ledger in which the customer's account is kept. The postings to the debit of customers of the goods sold to them will be carried out in the usual manner, and the gross

Dr. ADJUSTMENT ACCOUNT IN TOWN SOLD LEDGER Cr.

Date		£	s.	d.	Date		£	s.	d.
Jan. 31	To Cash received as per Town column of Cash Book	1,208	1	9	Jan. 1	By Balance b/d, being the total of the balances on the customers' accounts	2,743	16	8
	,, Discount (Cash Book)	24	6	3	Jan. 31	,, Sales as per Town column of Sales Book	1,426	18	2
	,, Returns as per Returns Inward Book, Town col.	42	8	6	Feb. 28	,, do. do.	1,107	5	3
Feb. 28	,, Cash and discount as above	1,124	5	3	Mar. 31	,, do. do.	1,384	12	6
	,, Bad Debt as per analysis of Journal ..	42	8	11		,, Dishonoured bill as per Journal	27	10	0
Mar. 31	,, Cash and discount ..	1,456	8	1					
	,, Bills Receivable as per Town col. of Bills Receivable Book ..	84	2	6					
	,, Balance c/d, agreeing with aggregate of debtors' balances ..	2,708	1	4					
		£6,690	2	7			£6,690	2	7
					April 1	By Balance b/d	2,708	1	4

Dr. TOWN SOLD LEDGER ADJUSTMENT ACCOUNT IN GENERAL LEDGER Cr.

Date		£	s.	d.	Date		£	s.	d.
Jan. 1	To Balance b/f, being total of balances on customers' accounts ..	2,743	16	8	Jan. 31	By Cash received as per Town column of Cash Book	1,208	1	9
Jan. 31	,, Sales as per Sales Book, Town column	1,426	18	2		,, Discount do. do. ..	24	6	3
Feb. 28	,, do. do. ..	1,107	5	3		,, Returns as per Returns Inward Book, Town column	42	8	6
Mar. 31	,, do. do. ..	1,384	12	6	Feb. 28	,, Cash and discount ..	1,124	5	3
	,, Dishonoured bill as per Journal	27	10	0		,, Bad debt as per Journal	42	8	11
					Mar. 31	,, Cash and discount ..	1,456	8	1
						,, Bills receivable as per Town column of Bills Receivable Book ..	84	2	6
						,, Balance c/d, agreeing with total of debtors' balances	2,708	1	4
		£6,690	2	7			£6,690	2	7
April 1	To Balance b/d	2,708	1	4					

total of the sales, both town and country, posted to the credit of the sales account in the general ledger. The cash, bills receivable, discount, and the returns inward—*i.e.*, from customers—will be posted to the credit of the customers' accounts, while the gross totals will be posted to the debit of the respective accounts in the general ledger relating to bills, returns, etc. This would complete the ordinary double entry of the various transactions, and the accuracy of the work could be tested by extracting a trial balance covering all the ledgers. But in order to obtain the desired result of balancing each ledger separately, we must obtain from the books of first entry the totals of the postings made to the debit and credit of customers in the two ledgers respectively. This is done by means of the town and country columns in each book, which are totalled at the end of the month, and the amounts posted to accounts opened at the end of each sold ledger, entitled General Ledger Adjustment Account.

The effect of this operation will be that each sold ledger will balance in itself, for, taking the case of the town ledger, the sales to town customers will have been separately posted to the debit of individuals, while the total of the town column in the sales book will be posted to the credit of the adjustment account. The cash, bills received, and discount, will have been posted to the credit of the customers individually, and the totals of the town columns in the cash and bills receivable books will be posted to the debit of the adjustment account. Returns inward will be posted to the credit of customers, and the total of the town column to the debit of the adjustment account. It will be apparent that if these entries have been correctly made the town ledger will balance in itself, for care has been taken to debit and credit to the adjustment account in total the items that have been credited and debited to the customers separately. It will be necessary to dissect the journal for any items affecting the town ledger in order that the totals may be entered on the adjustment account on the opposite side from that on which they were entered in the case of the customer. These items may consist of dishonoured bills, bad debts, special allowances, etc. The result will be, if the work has been accurately carried out, that the balance of the adjustment account will equal the aggregate of the balances of the other accounts in the ledger—*viz.*, those of the town customers. This balance is carried down at balancing time and shows at a glance the total of the customers' balances then owing.

General Ledger Adjustment. In order that the balancing of the books as a whole may be preserved, an adjustment account is raised in the general ledger for each of the other ledgers, and the entries made on these accounts will naturally be the reverse of those made in the adjustment accounts in those ledgers. In order that the working of the system may be thoroughly understood, specimens of the adjustment accounts in a town sold ledger and in a general ledger respectively are shown on the previous page.

In the case of a small business, with only three ledgers—*viz.*, sold, bought, and general ledgers—it might be more convenient to prepare monthly summaries by analysing or dissecting the books of first entry and showing in the form of an account the totals of the postings to the three ledgers. Thus, in the case of the bought ledger, the credit side of the cash book would be analysed, and the amounts which had been posted to the debit of persons whose accounts were kept in the bought ledger would be extracted, totalled, and entered on the credit side of the summary. The purchases book would give the total of the postings to their credit, and this would be entered on the debit side of the summary. Any returns outward would be taken from the returns book, and as these would have been posted in detail to the debit of the sellers, the total would be entered on the credit side of the summary. Any bills given to the creditors which have been posted to their debit would be entered in total on the credit side of the summary, which would then appear as below.

J. F. G. PRICE

Dr. SUMMARY OF BOUGHT LEDGER **Cr.**

Date		£	s.	d.	Date		£	s.	d.
Jan. 1	To Balance b/f. being total of the balances of the creditors' accounts	283	5	4	Jan. 31	By Cash paid to creditors, as per analysis of Cash Book	148	6	9
Jan. 31	„ Purchases as per Purchases Book	195	6	0		„ Discount allowed by creditors	5	6	0
						„ Returns outward ..	18	10	0
						„ Bills payable	50	0	0
						„ Balance c/d, agreeing with total of creditors' balances ..	256	8	7
		£478	11	4			£478	11	4
Feb. 1	To balance b/d	256	8	7					

A special Dictionary, explaining Commercial Terms and Phrases, appears at the end of the Self-Educator

Methods of Extracting Square Root and Cube Root. Measurement of Surface.

SQUARE ROOT AND CUBE ROOT

POWERS AND ROOTS

138. When a product consists of the same factor repeated any number of times it is called a *power* of that factor.

7×7 is the *second power*, or the *square* of 7.

$7 \times 7 \times 7$ is the *third power*, or the *cube* of 7.

A power of a number is generally expressed by writing the number only once, and placing after it, above the line, a small figure to show how many factors are to be taken. The small figure is called an *index*.

Thus, $7^2 = 49$; $7^3 = 343$; $7^4 = 2401$.

139. A number is called the *square root* of its square. Since $7^2 = 49$, the square root of 49 is 7.

The "square root of 49" is written $\sqrt{49}$.

Again, a number is called the *cube root* of its cube. $7^3 = 343$. Therefore, the cube root of 343 is 7.

The "cube root of 343" is written $\sqrt[3]{343}$.

A *perfect square* is a number whose square root is a whole number. A *perfect cube* is a number whose cube root is a whole number.

SQUARE ROOT

140. If a number can be put into prime factors, its square root can be written down by inspection.

Example. Find the square root of 27225.

Since $27225 = 3^2 \times 5^2 \times 11^2$.

$\therefore \sqrt{27225} = 3 \times 5 \times 11 = 165$ *Ans.*

141. We know that $\sqrt{1} = 1$, and $\sqrt{100} = 10$. Therefore, the square root of any number which lies between 1 and 100 lies between 1 and 10; *i.e.*, if a number contains *one* or *two* digits, its square root consists of *one* digit.

Similarly, since $\sqrt{100} = 10$ and $\sqrt{10000} = 100$, the square root of a number between 100 and 10000 lies between 10 and 100. That is, if a number contains *three* or *four* digits, its square root consists of *two* digits.

Proceeding in this way, we obtain a general result—viz., the square of a number has either twice as many digits as the number, or one less than twice as many.

Hence, to ascertain the number of digits in the square root of a perfect square, mark off the digits in pairs, beginning from the right. Each pair marked off gives a digit in the square root; and, if there is an odd digit remaining, that digit also gives a digit in the square root.

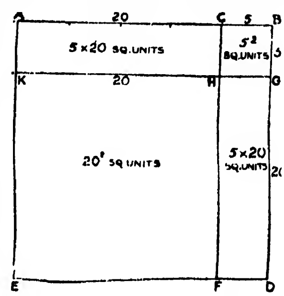
Examples. There are *three* digits in the square root of 546121, and *four* in the square root of 5774409.

For, marking off the digits from the right, we get in the first case 54,61,21, giving three digits in the square root, and in the second case 5,77,44,09, the odd digit giving the fourth in the square root.

The method of finding the square root of a given number depends on the *form* of the square of the sum of two numbers.

Consider the number 25, *i.e.*, 20 + 5. In the figure, let AB measure 25 units and BC 5 units. Then AC = 20 units. Draw the square ABDE, and draw CF parallel to BD.

Make BG = 5 units, and draw GK parallel to AB. Then it is easily seen that (1) ABDE contains 25^2 square units; (2) BCHG contains 5^2 square units; (3) each of the figures ACHK, GHFD, contains 5×20 square units; (4) HKEF contains 20^2 square units.



It follows that

$$25^2 = (20 + 5)^2 = 20^2 + \text{twice } 20^2 \times 5 + 5^2.$$

The result may be written in the form

$$25^2 = 20^2 + (\text{twice } 20 + 5) \times 5.$$

142. Suppose we are required to find the square root of 625. By Art. **141**, there will be two digits in the square root. The greatest perfect square which is not greater than 6 is 4—*i.e.*, 2^2. Hence, 2 is the first, or tens, figure of the root. Subtract this 20^2 from 625. The remainder is 225. Now, by Art. **141**, if 625 is a perfect square, this remainder must be equal to (twice 20 + digit required) × that digit. Twice 20, or 40, is therefore a *trial divisor*. Now, 40 divided into 225 gives 5 for quotient. We therefore try whether $(40 + 5) \times 5$ is equal to 225; and, finding this to be the case, we know that 5 is the digit we wanted, and that the square root of 625 is 25.

Example 1. Find the square root of 74529.

$$\begin{array}{rr}
 & 7,45,29(200 + 70 + 3 \\
200^2 = & 4\ 00\ 00 \\
\hline
 & 3\ 45\ 29 \\
70 \times (\text{twice } 200 + 70) = & 3\ 29\ 00 \\
\hline
 & 16\ 29 \\
3 \times (\text{twice } 270 + 3) = & 16\ 29 \\
\hline
\end{array}$$

Explanation. There will be three digits in the root. The greatest square number below 7 is 4, *i.e.*, 2^2. Hence, 2 is the hundreds figure of the root. We subtract 200^2, and obtain a remainder, 34529. We now have twice 200, *i.e.*, 400, for a trial divisior; and 400 divided into 34529 gives 80. By trial, we find 80 is too large, since

$80 \times (400 + 80)$ is greater than 34529. We therefore try 70. This gives $70 \times (400 + 70) = 32900$, and this, when subtracted from 34529, leaves 1629.

We have now completed the subtraction of 270^2 from the original number, and found a remainder 1629.

Next, use twice 270, *i.e.*, 540, for a trial divisor. 540 into 1629 gives 3. And $3 \times (540 + 3) = 1629$, so that, after subtraction, there is no remainder.

Also, since [Art. **141**] $273^2 = 270^2 + (\text{twice } 270 + 3) \times 3$, we have now subtracted 273^2 from the given number 74529. Hence, as there was no remainder, we know that $273^2 = 74529$, so that the required square root is 273.

The working is abbreviated as follows :

```
    7,45,29(273 Ans.
 47)3 45
543)16 29
```

Explanation. As above, we find the first digit of the answer is 2. Square 2, and subtract from 7, in one process. Remainder is 3. Write the next pair of digits, 45, after the 3, giving 345.

Double the digit of the answer, which has already been found, obtaining 4 as a trial divisor. 4 into 34 gives 8, which, as we saw above, is too large. Try 7. This proves small enough, so we write the 7 after the 4 of our trial divisor, and put 7 into the answer. Multiply 47 by 7 and subtract from 345. Remainder is 16. Bring down the remaining two digits, 29, of the given number. Double the 27 of the answer, obtaining 54 as trial divisor. 54 into 162 gives 3. Write 3 after the 54 and 3 in the answer. Multiply 543 by 3 and subtract from 1629. There is no remainder, and 273 is the required square root.

Example 2. Find the square root of 2310·7249

```
      23,10·72,49,(48·07 Ans.
  88 ) 7 10
9607 )  6 72 49
```

Mark off the digits in pairs *from the decimal point*. Proceed as in Example 1. After obtaining the first two figures of the square root, 48, we reach the decimal point in the given number. We therefore put a decimal point in the answer, and bring down the next two figures, 72. The trial divisor is 96, and 96 into 67 gives 0. Put 0 in the answer, and bring down 49. The trial divisor is now 960, and this gives 7 for the remaining digit.

143. In the case of a number which is not a perfect square, the process of finding the square root can be continued to as many decimal places as we please, but never terminates.

The square root will not be a recurring decimal, for a recurring decimal can be expressed as a vulgar fraction in its lowest terms ; and, if we square such a fraction, the numerator and denominator will still be prime to one another—*i.e.*, the square is a *fraction*, and so, of course, cannot be equal to the given number.

Example. Find the value of $\sqrt{2}$ to four places of decimals.

```
     2   (1·4142 Ans.
   24)100
  281 )400
 2824)11900
28282 )60400
        3836
```

We consider that 2 is 2·0000... and bring down 00 at each stage of the work.

A number such as $\sqrt{2}$, or $\sqrt{5}$, which cannot be exactly expressed as a decimal is called an *Incommensurable Number*, or a *Surd.*

144. To obtain the square root of a vulgar fraction we take the square root of the numerator and the square root of the denominator.

For, the square of $\frac{3}{4}$ is $\frac{3}{4} \times \frac{3}{4}$, *i.e.*, $\frac{9}{16}$. Therefore,

$$\sqrt{\frac{9}{16}} = \frac{3}{4} \text{ or } \frac{\sqrt{9}}{\sqrt{16}}.$$

In the case of a mixed number, we reduce it to an improper fraction and proceed in the same way.

Example 1. Find the square root of $19\frac{30}{49}$.

$$19\tfrac{30}{49} = \tfrac{961}{49}.$$

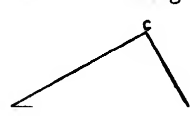
$$\therefore \text{ Square root} = \frac{\sqrt{961}}{\sqrt{49}} = \frac{31}{7} = \underline{4\tfrac{3}{7} \textit{ Ans.}}$$

If the denominator is not a perfect square, we multiply both numerator and denominator by such a number as will make the denominator a perfect square.

Example 2. Find the square root of $\frac{3}{5}$, to three places of decimals.

$$\sqrt{\frac{3}{5}} = \sqrt{\frac{3 \times 5}{5 \times 5}} = \sqrt{\frac{15}{25}} = \frac{\sqrt{15}}{5} = \frac{3{\cdot}872\ldots}{5}$$
$$= {\cdot}774 \ldots \textit{ Ans.}$$

145. Applications of Square Root. In the course on GEOMETRY it will be proved that if one angle of a triangle is a right angle then the square on the side opposite the right angle is equal to the sum of the squares on the other two sides. This property enables us to find the length of the third side of a right-angled triangle when we know the lengths of the other two sides.



Thus, if the angle C is a right angle, and we know that BC = 3 and CA = 4, then

$$AB^2 = 3^2 + 4^2 = 9 + 16 = 25.$$
$$\therefore AB = \sqrt{25} = 5.$$

Or, if we know that AB = 37 and AC = 35, then

$$BC^2 = AB^2 - AC^2 = 37^2 - 35^2 = 144.$$
$$\therefore BC = \sqrt{144} = 12.$$

Example. How long is the diagonal of a rectangular field whose length is 153 yd. and breadth 104 yd. ?

$$\text{The square of the diagonal} = 153^2 + 104^2$$
$$= 23409 + 10816$$
$$= 34225.$$
$$\therefore \text{Diagonal} = \sqrt{34225} = \underline{185 \text{ yd. } \textit{Ans.}}$$

146. The following is a common type of problem in square root.

Example. The members of a club each subscribed as many sixpences as there were members of the club. The total sum was £455 12s. 6d. How many members were there?

$$\begin{array}{rl}
\pounds\ \ \text{s.}\ \ \text{d.} & \\
455\ \ 12\ \ \ 6 & \\
\underline{20} & \\
\overline{9112}\ \text{s.} & \\
\underline{2} & \\
1{,}82{,}25 & \text{sixpences } (\underline{135 \text{ members } \textit{Ans.}} \\
23)\ \overline{82} & \\
265)\ \overline{13\ 25} &
\end{array}$$

Explanation. Evidently the number of sixpences subscribed is the square of the number of members. We therefore reduce the given sum to sixpences, and find the square root.

Other problems will be met with after the chapter on Areas and Volumes.

CUBE ROOT

147. If we can find the prime factors of any perfect cube, we can write down its cube root by inspection.

Example. Find the cube root of 74088.

$$\begin{array}{r|r}
8 & 74088 \\
9 & \overline{9261} \\
3 & \overline{1029} \\
7 & \overline{343} \\
7 & \overline{49}
\end{array}
\qquad
\begin{aligned}
\therefore\ 74088 &= 8 \times 9 \times 3 \times 7 \times 7 \times 7 \\
&= 2^3 \times 3^3 \times 7^3 \\
\therefore\ \sqrt[3]{74088} &= 2 \times 3 \times 7 \\
&= \underline{42\ \textit{Ans.}}
\end{aligned}$$

148. Since $1^3 = 1$ and $10^3 = 1000$, therefore, the cube of a number which lies between 1 and 10 lies between 1 and 1000, *i.e.*, the cube of a number of one digit contains either one, two, or three digits.

Again, since $10^3 = 1000$ and $100^3 = 1000000$, the cube of a number of two digits contains either four, five, or six digits.

Proceeding in this way, we see that *the cube of a number contains three times, or one less or two less than three times, as many digits as the number.*

Hence, to find the number of digits in the cube root of a given number, we mark off the digits in sets of three, beginning at the decimal point, and marking both to the right and to the left.

149. The simplest method of finding the cube root of numbers whose prime factors are not known is analogous to the method of finding square root, being based upon the form of the cube of the sum of two numbers.

The student can easily verify for himself that

$$\begin{aligned}
67^3 &= 60^3 + 3 \times 60^2 \times 7 + 3 \times 60 \times 7^2 + 7^3 \\
&= 60^3 + (3 \times 60^2 + 3 \times 60 \times 7 + 7^2) \times 7.
\end{aligned}$$

If, then, from some given number, we first subtract 60^3, and then subtract $(3 \times 60^2 + 3 \times 60 \times 7 + 7^2) \times 7$, we shall, altogether, have subtracted 67^3. If we now have no remainder we conclude that the given number is 67^3, *i.e.*, that its cube root is 67.

It should be noticed that 3×60^2 is the same thing as $6^2 \times 300$, and that $3 \times 60 \times 7$ is the same as $6 \times 30 \times 7$. In working examples we shall use the second of these forms, as there is possibly less chance of the student making any mistake in forming the "trial divisors."

By multiplication we know that $67^3 = 300763$. Let us consider how, when we are only given the number 300763, we find that its cube root is 67.

$$\begin{array}{rr|l}
 & & 300{,}763(67 \\
6^3 = & & 216 \\
6^2 \times 300 = & 10800 & \overline{84\ 763} \\
6 \times 30 \times 7 = & 1260 & \\
7^2 = & 49 & \\
 & \overline{12109} & 84\ 763
\end{array}$$

We first mark off the digits in threes, beginning at the decimal point—*i.e.*, in this case, at the right-hand digit. Next, we know that $6^3 = 216$, and $7^3 = 343$. Hence, since 300 lies between these numbers, we know that the first digit of our answer is 6. Write the 216 under the 300, and subtract. In reality, of course, we are subtracting 60^3 from 300763. The remainder is 84763. We now form our trial divisor, by squaring the digit already found and multiplying by 300 [see above]. Thus, $6^2 \times 300 = 10800$. Now 10800 into 84763 appears to give 7 for the next digit of our answer. We try 7, forming the rest of our divisor by taking $6 \times 30 \times 7 = 1260$, and $7^2 = 49$, and adding the three lines. This gives 12109, and, on subtracting 7 times 12109 from 84763, there is no remainder. Hence, 67 is the required cube root.

Example. Find the cube root of 14706·125.

$$\begin{array}{rr|l}
 & & 14{,}706{\cdot}125{,}(\underline{24{\cdot}5\ \textit{Ans.}} \\
2^3 = & & 8 \\
2^2 \times 300 = & 1200 & \overline{6\ 706} \\
2 \times 30 \times 4 = & 240 & \\
4^2 = & 16 & \\
 & \overline{1456} & 5\ 824 \\
24^2 \times 300 = & 172800 & 882\ 125 \\
24 \times 30 \times 5 = & 3600 & \\
5^2 = & 25 & \\
 & \overline{176425} & 882\ 125
\end{array}$$

Explanation. Mark off the digits in threes. By inspection, the first digit of the answer is 2. Subtract 2^3 from 14, obtaining remainder 6. Bring down the next set of digits, making 6706. Form the next divisor by taking $2^2 \times 300 = 1200$. This, divided into 6706, would appear to make the next digit of the answer be 5. If, however, we use 5, and complete the divisor, we find that 5 is too big. Try 4, *viz.*, $2 \times 30 \times 4 = 240$, and $4^2 = 16$. Adding, the divisor is 1456. Subtract 4 times 1456 from 6706. The remainder is 882. Bring down the next set of digits, 125, and, since these digits form the decimal part of the given number, we put a decimal point in the answer. Proceed as before—*i.e.*, square the part of the answer already found, and multiply by 300. Thus, $24^2 \times 300 = 172800$. Dividing this into 882125 gives 5 for quotient, and we complete the divisor by taking $24 \times 30 \times 5 = 3600$, and $5^2 = 25$, which, on addition, makes 176425. Subtract 5 times 176425 from 882125, and there is no remainder. Hence the required cube root is 24·5.

150. A great amount of labour can be saved in forming the trial divisors, after the first. Thus, in the previous example, the second trial divisor, 172800, can be found without working out the value of $24^2 \times 300$.

$$\left.\begin{array}{rl} 2 \times 30 \times 4 & = 240 \\ 4^2 & = 16 \\ & \overline{1456} \\ \text{Repeat } 4^2 & = 16 \\ 24^2 \times 300 & = \overline{1728}00 \end{array}\right\}$$

The rule is as follows: In the first divisor, already obtained, repeat the $4^2=16$, and add together everything but the first trial divisor, 1200. This gives 1728. *If we now add two noughts we obtain the value of* $24^2 \times 300$.

In actual work, we repeat the 16 mentally, and write down nothing more than was shown in the working of the example.

151. The cube root of a number which is not an exact cube can be found to any required number of decimal places. If the decimal part of the given number does not contain an exact number of sets of three digits, we simply put on ciphers to make up the set, and, of course, use three ciphers for each succeeding set.

Example. Find the cube root of 4·9590954051 to four places of decimals.

$$\begin{array}{rr|l} & & 4{\cdot}959,095\ 405,100,(\underline{1{\cdot}7053\ldots} \\ & & 1 \qquad\qquad\qquad\qquad \underline{\textit{Ans.}} \\ 1^2 \times 300 = & 300 & \overline{3\ 959} \\ 1 \times 30 \times 7^2 = & 210 & \\ 7^2 = & 49 & \\ & \overline{559} & 3\ 913 \\ 170^2 \times 300 = & \overline{8670000} & 46\ 095\ 405 \\ 170 \times 30 \times 5 = & 25500 & \\ 5^2 = & 25 & \\ & \overline{8695525} & 43\ 477\ 625 \\ 1705^2 \times 300 = & \overline{872107500} & 2617\ 780\ 100 \\ 1705 \times 30 \times 3 = & 153450 & \\ 3^2 = & 9 & \\ & \overline{872260959} & 2616\ 782\ 877 \\ & & \underline{997\ 223} \end{array}$$

Explanation. After obtaining the first two figures, 17, of the answer, the remainder is 46. Bringing down the next three figures we obtain 46095. Our trial divisor (obtained, as already explained, by adding together 210, 49, 559, and 49, and affixing two noughts) is 86700. This, divided into 46095, evidently gives 0 for the next figure of the answer. Therefore, after putting 0 in the answer, we bring down the next three figures, and obtain 46095405. The trial divisor is now $170^2 \times 300$, which means we have simply to put two more noughts on to the 86700 already obtained. We then proceed as before.

EXAMPLES 18

By the method of factors, find the value of

1. $\sqrt{74529}$. 2. $\sqrt{4624}$.
3. $\sqrt{27300625}$. 4. $\sqrt[3]{456533}$.
5. $\sqrt[3]{18399744}$. 6. $\sqrt[3]{1520875}$.
7. Find the square root of 98765·6329.
8. Find the square root of $3\frac{1}{7}$ correct to three places of decimals.
9. Find the cube root of 30959144, and of 9269337·400720047.
10. Find the cube root of $13\frac{203}{512}$.
11. The side of a square is 5 ft. Find, to three places of decimals, the length of the diagonal.
12. A man spent £19 5s. 4d. in buying books. On the average, each book cost as many pence as there were books. How many books did he buy?
13. On a tour, a man spent each day 5 times as many sixpences as the number of days the tour lasted. If he spent, in all, £6 2s. 6d., how long did the tour last?
14. The foot of a ladder 50 ft. long is 14 ft. from the wall of a house, and its other end just reaches the top of a window. When the foot of the ladder is moved to a distance of 30 ft. from the wall, the other end just reaches the bottom of the window. What does the window measure from top to bottom?

MEASUREMENT OF SURFACE

152. The chief surface with which we are concerned in arithmetic is the *rectangle*

A rectangle is a four-sided figure in which each side is equal in length to the opposite side, and each of the angles is a right angle.

The length and breadth of a rectangle are called its *dimensions.*

If the length and breadth of a rectangle are equal, the figure is called a *square.* We see, then, that the unit of surface, the *square yard* in the tables on page 415, means a square surface, each of whose sides measures a linear yard.

153. The number of square feet (or inches, or yards) in the area of a rectangle is equal to the number of linear feet (or inches, or yards) in the length multiplied by the number of linear feet (or inches, or yards) in the breadth.

This statement is usually abbreviated into

Length × Breadth = Area.

154. Since, Length × Breadth = Area, it follows that Length = Area ÷ Breadth, and Breadth = Area ÷ Length.

Example 1. A plot of ground containing 1 acre is 44 yd. wide. What is its length?

$$\text{Length} = \frac{4840}{44}\text{yd.} = \underline{110\text{ yd. } \textit{Ans.}}$$

Example 2. It costs £5 10s. 3d. to carpet a floor 21 ft. long with carpet at 3s. a square yard, Find the breadth of the floor.

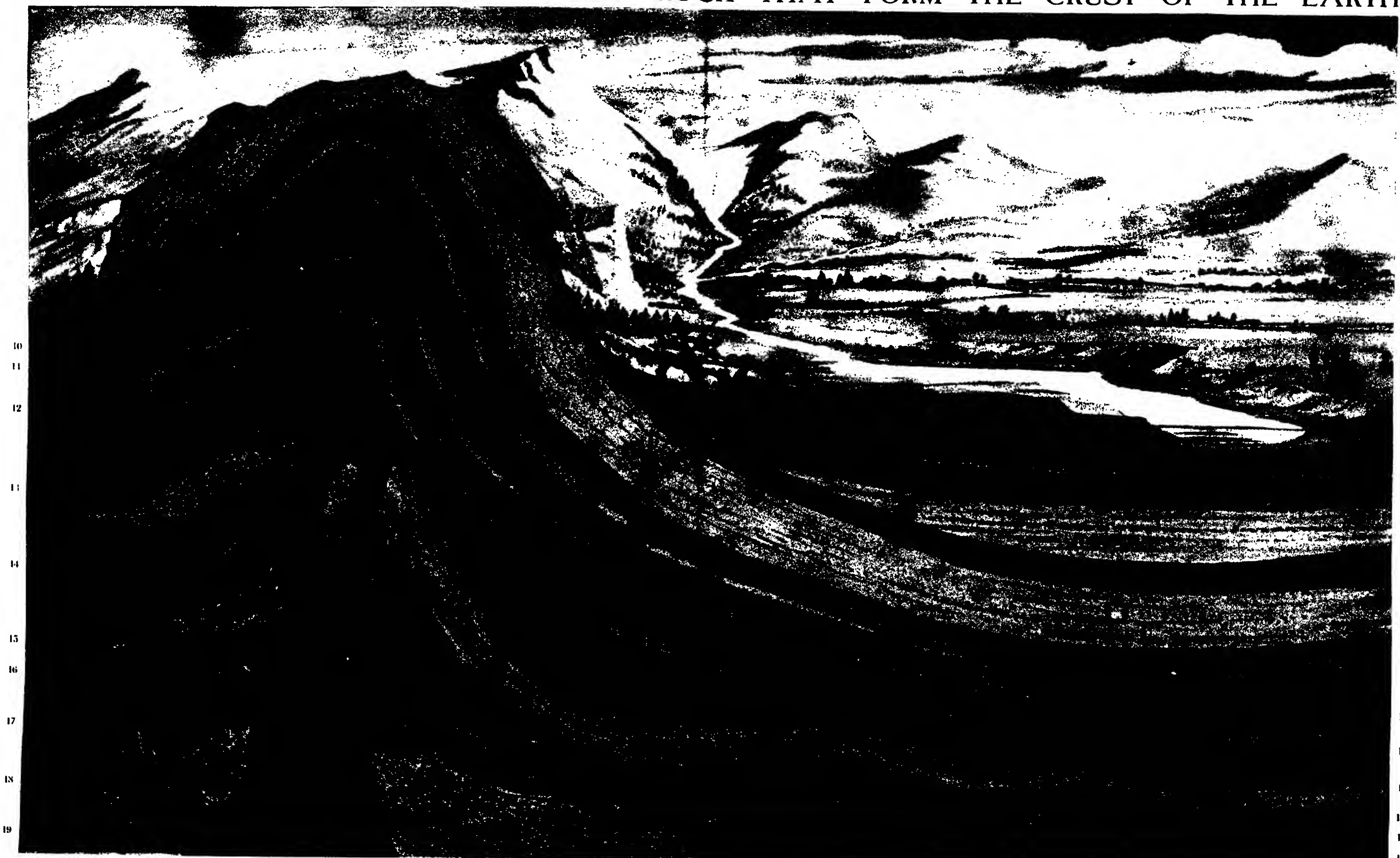
Here, the number of square yards in the floor is equal to the number of times 3s. is contained in £5 10s. 3d.

We must then be careful to divide the number of square *yards* in the floor by the number of *yards* in the length, and not by the number of *feet.* Hence,

$$\begin{aligned} \text{Area of floor} &= \frac{\text{£5 10s. 3d.}}{\text{3s.}}\text{ square yd.} \\ &= \frac{110\frac{1}{4}}{3}\text{ square yd.} \\ \text{Length of floor} &= 21\text{ ft.} = 7\text{ yd.} \\ \therefore \text{Breadth of floor} &= \frac{110\frac{1}{4}}{3 \times 7}\text{ yd.} = \frac{21}{4}\text{ yd.} \\ &= 5\tfrac{1}{4}\text{ yd.} = \underline{15\text{ ft. } 9\text{ in. } \textit{An.}} \end{aligned}$$

H. J. ALLPORT

THE BUILDING-UP OF THE LAYERS OF ROCK THAT FORM THE CRUST OF THE EARTH



A TYPICAL SECTION SHOWING THE ORDER IN WHICH THE CHIEF STRATA OF THE EARTH WERE LAID DOWN, AND THE SUCCESSIVE GEOLOGICAL PERIODS THAT THEY REPRESENT

The strata, shown in their approximate colours, are as follow. 1. Pleistocene, glacial, and human period. 2. Pliocene crag. 3. Miocene. 4. Oligocene. 5. Eocene—clays. 6. Cretaceous—chalk, greensand, and gault. 7. Neocomian clays and greensand. 8. and 9. Jurassic—(8) Oolitic limestone, which has been worn down at the head of the mountain, and (9) Liassic. 10. Triassic—sandstones and limestone. 11. Permian. 12. Carboniferous coal, millstone grit, and limestone. 13. Devonian old red sandstone and flagstones. 14. Silurian—limestones, sandstones, and shales. 15. Ordovician. 16. Cambrian—limestones, shales, slates, and flagstones. 17. Igneous vein of trap rock - basalt. 18. Pre-Cambrian—Torridonian and Laurentian. 19. Archæan granite. In the centre of this section the upheaval of the earth has brought about a geological "fault."

The Old View of Leisure and the New. Efficiency, not Ease, now the Aim of Spare Moments.

THE RIGHT USE OF LEISURE

THERE was a time, not so long ago but that living people can remember it, when the linking together of two such words as "leisure" and "success" would have been regarded as highly incongruous, except that leisure was a great reward of success. Leisure as a contributor to success was unthinkable. They belonged to different ends of life. Success was an outcome of ceaseless work, in youth and prime, and leisure anywhere in those neighbourhoods was looked upon as the playground of the devil.

In looking at these things now we have changed our position a long way from the point of view of our forefathers; and with good reasons. For what they called work was quite unlike what we call work; our need for leisure is comparatively new; and the methods of using it far more varied and incomparably richer in results than were theirs.

The long, slow operations they called work did not drive them to demand, imperatively, relief through leisure; and, when won, their leisure was comparatively colourless, and soon in danger of bringing them to the state of not knowing what to do with themselves. In truth we have few lessons to learn from the leisure of the past—Old Leisure, as George Eliot calls it, in playful impersonation. It was a state into which people declined, and sometimes still decline, but that only asks from us now a passing reference.

"Leisure is gone," said the creator of Adam Bede—"gone where the spinning-wheels are gone, and the pack-horses, and the slow waggons, and the pedlars who brought bargains to the door on sunny afternoons. Ingenious philosophers tell us that the great work of the steam-engine is to create leisure for mankind. Do not believe them; it only creates a vacuum for eager thought to rush in. Even idleness is eager now. Old Leisure was quite a different personage. He was a contemplative, rather stout gentleman, of excellent digestion, of quiet perceptions undiseased by hypothesis. He lived chiefly in the country, among pleasant seats and homesteads, and was fond of sauntering by the fruit-tree wall, and scenting the apricots when they were warmed by the morning sunshine."

We fancy that Old Leisure is still alive, but he is not the leisure who matters much to the modern world. The Leisure to be introduced here is a thoroughly practical fellow, partner to Effort through the busiest years of life.

Leisure is simply free time; and its three uses, all of which may contribute to making life a success, are, first, as an opportunity for preparation; second, as a recreative interlude; and, third, as the reward of a fuller life, after some preliminary success has been attained. Putting these three uses into other words, before commenting on each separately, we may use leisure to widen and deepen our knowledge, experience, and skill so as to be ready for better work; we may use it to refresh ourselves for the next round of duty; and if our working life has been circumscribed, we may win our way through to a leisure which will enable us to reap an aftermath of enjoyment denied to us by our more strenuous years.

Leisure is the raw material offered to us for our use by Life outside the routine of our business. We may take it or leave it. Each of us has some of it easily available for making himself a more efficient man. "Yes," an objector may say; "but if we use it seriously it no longer remains leisure." But is not that largely a matter of taste, and of self-schooling into utilisations of time that will be at once useful and delightful?

For instance, A., B., C., and D. all finish their routine duties, by which they earn a living, at the same hour, and have two or three hours a day for clear leisure. A. devotes all this time to sport—tennis, cricket, football, boating—or to thoughts, or business, associated with sport, and he feels he has a right to do this in a spirit of pure leisure. B. has no such interests, but slacks away his time, perhaps with

some casual attention to one or two trifling hobbies. But C. realises that the business in which they are all engaged branches out into many ramifications, touches several distinct departments of knowledge, requires somebody, in superior positions, to understand its commercial, or industrial, or scientific bearings, and so sets himself to read all round the subject, to think out its problems, and prepare himself some day to take almost any part in its operations.

Every step in such a study becomes naturally interesting. So far from inquiry being a labour, it may even need to be guarded against, lest it become too absorbing, and trench on the time that may wisely be given to physical exercise and mental relaxation.

Then, D., the fourth member of the group, less drawn by business considerations, feels he can best keep up his mental fitness by some general course of reading, and organises a portion of his leisure accordingly. Do those who, in this way, make a definite use of their leisure spoil it as leisure, in comparison with those who fritter it away? Does the man who reads as he travels forfeit his leisure in comparison with the man who talks golf? The interest felt by the one in his preoccupation is as natural and as truly leisurely as the interest felt by the other, while the one has a definite use and the other only an aimless drift.

The plain truth is that, next to diligence in business, success depends on diligence in some interesting activity outside business—that is, an organisation of a substantial part of our leisure. In a multitude of cases this over-time, on which men's tastes and aptitudes could work freely, has furnished the opportunity for success later in life.

If you watch closely men who are said to be lucky, because they have made new and successful departures in business, or have been singled out and trusted for great responsibilities, you will observe that they were given their chances, or seized their chances, because during their leisure they prepared themselves for the work which they afterwards undertook, while others thought that the sole use of leisure was to "live and lie reclined," careless of the life that is not leisure.

At the present moment a director of one of the most successful North of England firms—known in every part of the world—owes his chance of gaining a commanding position solely to the fact that he not only learned how to converse in a certain foreign tongue but could express in it all the technicalities of an elaborate business. A foreigner of great trade influence, but dumb in all languages except his own, visited the works, and was received by the head of the firm; but no satisfactory means of talk and technical explanation could be established until someone remembered that in the office was a youth who had a rather annoying interest in languages. He was hastily fetched to join the procession round the works, and, to the immense relief of the "management," was soon chattering easily with the visitor, who was delighted by the lucidity of explanations given in his own tongue. That night the clerk out of the office dined at the house of the head of the firm with the distinguished guest, and the next day was no longer a clerk in the office, but attached confidentially to the chairman of the company. Now he is the most active of that company's directors.

It is not often that such a dramatic promotion rewards the wise use of leisure, but in smaller ways, that have an immense aggregate effect, intelligent preparation to seize opportunities has its reward again and again, till in the end substantial success is won.

And it is impossible to begin too early to value the uses to which leisure may be put. Often, for example, between school-days and the time when settled work begins, there is an interval of unengaged time. The youth feels he has done with school—a fond delusion, for all life is school!—and that he may well have a rest before starting on routine duty—a most deplorable interregnum! This is the kind of leisure that justified some of the old writers—as, for example, Young in his "Night Thoughts"—describing leisure as a curse. Through it the habit of application is likely to be lost, as well as much time that might have stored some reserve of knowledge. Youth knows of no such process as lying fallow—the gardening of the mind must go on, or "things rank and gross in Nature" will take possession of it.

It is no argument whatever to point to men who in later life arrived at well-deserved eminence but in youth seem to have carried leisure to the length of

laziness. Robert Louis Stevenson may be named as the type. But Stevenson was always working a mind insatiable in its curiosity and its search for expression. He might sit listening to the band playing in the garden, but he was busy weaving all the sights and sounds around him, and his own seeming inertia, into a philosophy strangely compounded of shrewdness and romance. The world will forgive anyone for being casual, *if he is a Stevenson.*

Lazy people never realise how much work is done by others who only seem lazy. They do not realise how vigorously such people use scraps of leisure, or how intensely they apply themselves when they work. The writer once knew a successful student who was regarded as a perfect exponent of the most admirable laziness, because only once in his whole career did he rise for "early class" before breakfast, and that was when a meeting was held to protest against all early classes. Then he rose and presided.

Yet, in reality, he was probably the hardest worker in the college, judged by activity of mind when he was out of bed, and by intensity of application when he professed to work. The slacker and the waster of time are often self-deceived when they see others apparently "taking it easy." What they see may be the temporary relaxation of strenuous workers. And especially are they deceived if they fail to understand how all successful workers forge scraps of leisure into usefulness.

In this age of daily travel it is no uncommon thing for an eighth of a man's waking life to be passed in moving to and from his place of occupation. Quite half of that eighth is leisure, capable of a well-considered use. All that is needed is that we shall decide first to what use the time shall be put, or which of our mental or business resources it shall enrich, and then that we shall organise its fruitful appropriation.

But the man who works with a will at his own business, and also makes a careful use of a reasonable share of the time that is not occupied by that business, will certainly need at intervals the second kind of leisure that has been mentioned—the recreative interlude. Sooner or later he will discover that the nightly relaxation of home is not enough. He needs to break away for a change as the best form of rest, and such organised leisure will not only prove indispensable to success, but may be the only safeguard against positive failure. Without recuperation from well-planned leisure, the racket of business and the attempt to live up to the pace of modern business machinery will wear out the strongest.

But here arises one of the most insidious of the dangers of modern life. How can a man distinguish between the leisure that is really needed and the leisure that is wished for? Leisure both for recuperation and as a reward during the closing years of life has been so skilfully organised that it has become highly attractive, and its influence is likely to wean us from duty unless we are strictly faithful to ourselves. We need to distinguish firmly between needed rest and lazy rest. A hundred golf-courses are dotted with men who pretend to be recuperating, when they are only pleasantly "passing" the time which they ought to be using diligently. Many a man who thinks he is worn by work is only worried by a desire to shirk work and take an easier course. His instinct leads him towards that demoralising misnomer, a "life of leisure"—as if in persistent leisure there could be any genuine vitality!

Let us suppose, then, that, without self-deception, genuine labour demands from leisure a physical and mental renewal of strength, how can that recuperation be secured so as to contribute plentifully to our future success? Are short or long holidays best? The sound reply to these questions is that temperaments differ enormously, and each of us may wisely vary, from time to time, the method and mapping out of his leisure.

Take two extremes as illustrations. They are genuine examples. In one instance a man who is preoccupied intellectually, with his brain always on the whirl, finds his greatest relaxation in social intercourse. The fireside circle where talk goes round is his height of bliss, and from it he emerges rejuvenated. It allows his mind to run down just enough. His longer holidays must be spent where there can be a pleasant stir of an intellectual kind. Loneliness or stagnation would be torture. The bow must be slacked a little, but not unbent.

In the other case a prodigious worker, carrying great responsibilities, immersed in business involving delicate problems, goes home to bed at the week-end, and stays there till the call back to work on

Monday morning cannot be disregarded. The only change from bed is to baths and massage. What common rule can be laid down that would include those methods of refreshment? They are too far apart for any bracket to enclose them

To some of us the secret of refreshing change is in finding new scenes, or in reviving the sharply romantic impressions which the scenes we revisit first made on us. But our neighbour, as likely as not, will be worried by unfamiliarity, and receive the healing balm of the spirit most readily from the resting-place which he knows best. To some the brief holiday is the only real holiday, for a longer absence from formal duty would bring a throng of harassing business doubts that would more than counterbalance all the good holiday effects. Others, again, have the enviable power of putting routine life right away, while they refresh and refit during a long and thoroughly rehabilitating pause. They can steep themselves in sheer forgetfulness, on mountain, stream, or sea, and feel unalloyed gladness in being out of call from the whole world.

Probably this is the best of all forms of the leisure that has a recruiting effect. Whether it has the supreme virtue or not can be judged by its final effects—the true test of the efficacy of all leisure, and its contribution towards later success.

That test is that it should send the holiday-maker back to his work with gusto. It should make him forget for the time being that work *is* work. He should bear his burden as if it were a decoration. He should rejoice as a strong man to run a race. There are people who always return from a holiday bad-tempered. Their first impulse is to find fault with what has been done in their absence, instead of feeling gratitude for the work of substitutes. They give everybody a distasteful day or two until things have settled down afresh. In all such cases it may be doubted whether leisure has been used successfully. It should have won back youth, vim, buoyancy, and good nature, and have stored a reserve of strength and overcoming spirit against the demands made by the dragging days when slow fatigue will return, and head us off towards failure, and only be repelled by another resort to refreshing leisure.

A READER," FROM THE PAINTING BY MEISSONIER

We have said little about the well-won leisure that should come to every honest worker towards the close of life, but two or three points in it are of master importance. One is that nobody ever truly enjoys leisure after earliest youth unless he has won it by effort. Inherited leisure cannot have the true relish, and any leisure which degenerates into laziness wears out. Therefore the leisure natural in some degree to age should be diversified by wisely planned effort of some kind, except, perhaps, in man's extremest years. Otherwise the leisure that has contributed through life to success, and later become itself a form of realised succ becomes a drag. Leisure that leave with nothing to do—with no use—i last calamity.

JOHN DE

Grouping of Mountains and Rivers around the Fichtel Gebirge. The Rhine Highlands. The German States. Climate. Products. North Germany. River Basins.

THE GERMAN EMPIRE

In our view from the summit of the Alps, and again in tracing the course of the Rhine, we have seen something of the second great geographical feature of Europe—the Central Highlands. These are a broken system of forested mountains, nowhere rising above a few thousand feet, which stretch across Europe at the northern base of the Alps.

We grouped the complicated topography of the Alps round the St. Gotthard mass and the mountains and rivers flowing from it. There is a similar point in the Central Highlands, a sort of hub from which mountains and rivers radiate like the spokes of a wheel. This is the Fichtel Gebirge, or Pine Mountains, clothed, as the name shows, with forests of pine. Look now at the rivers flowing from it, north, south, east, and west, to all four points of the compass. They are: (1) To the north the Saale, the most important tributary of the Elbe, corresponding with the Reuss in the St. Gotthard series; (2) to the south the Naab, flowing to the Danube, corresponding with the Ticino; (3) to the east the Eger, flowing to the Elbe, corresponding with the Rhine; (4) to the west the Main, flowing to the Rhine, corresponding with the Rhone. Indeed, the resemblance in the courses taken by the rivers rising in the St. Gotthard and those rising in the Fichtel Gebirge is remarkable.

Alternating with these rivers are the mountain ranges separating their basins. Look these out carefully in an ordinary map. From the Fichtel Gebirge spring to the north-east the Erz Gebirge, or Ore Mountains, and to the south-east the Böhmer Wald, or Bohemian Forest, enclosing two sides of the diamond-shaped province of Bohemia, politically part of Austria. Between them and the Riesen Gebirge and Moravian Highlands, which enclose the two remaining sides, is the Elbe, flowing to the North Sea. Between the Sudetes and Moravian Mountains to the west and the Carpathian Mountains to the east is the important gap, known as the Moravian Gate, with the Oder flowing north to the Baltic, and the March flowing south to the Danube. Compare these with the Saale and Naab farther west. The Vistula rises a little east of the Oder in the northern slope of the Carpathians, and flows across Russian Poland and the North German Plain to the Baltic.

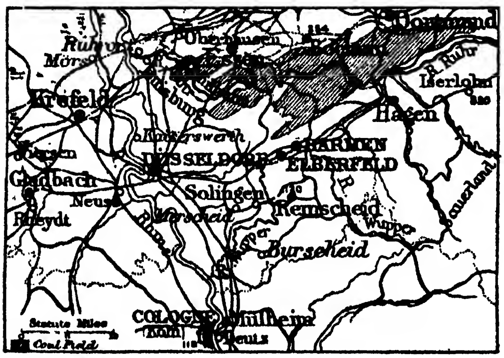
The arrangement of mountains and rivers west of the Fichtel Gebirge is more complicated. We can make out three sides of a western diamond, but not so clearly as in the case of Bohemia. From the Fichtel Gebirge to the north-west springs the Thüringer Wald, or Thuringian Forest, connected by lower heights with the Harz to the north, and the Vogelsberg and Rhön to the west. This forms one side of a diamond. The second is formed by the Franconian Jura, springing south-west from the Fichtel Gebirge, and continued by the Swabian Jura. At the western end of the Swabian Jura we have another important meeting-point of mountains and rivers, from which radiate, in addition to the Swabian Jura, the Rhine Highlands, running north, and the French Jura, running west. The last-named separate the Rhine from the Rhone, and connect the Central Highlands with the Alps. The rivers are the Rhine, breaking through the mountains and turning north at what we might call the Swiss Gate, and the Danube, flowing east, between the southern slopes of the Central Highlands and the northern slopes of the Alps.

These have already been described, but here their connection with the rest of the Central Highlands is what we must be quite clear about. The Rhine has cut a wide valley across this broad eastern part of the Central Highlands, dividing them into the Eastern and Western Rhine Highlands. These are again broken up by the tributaries coming in from east and west. This gives us on the east the Schwarzwald, or Black Forest, the Odenwald, the Taunus, and the Westerwald. On the west are the Vosges, opposite the Black Forest, the Haardt, opposite the Odenwald; the Hunsrück, opposite the Taunus; and the Eifel, opposite the Westerwald.

The Eifel and Westerwald represent the third side of the western diamond.

On the east, the Neckar comes in between the Black Forest and Odenwald, the Main between the Odenwald and Taunus, and the Lahn between the Taunus and Westerwald. On the west the rivers coming down between the Vosges, Haardt, and Hunsrück are unimportant, the only considerable western tributary being the Moselle, between the Hunsrück and Eifel. The relation of all these highlands to each other should be studied in the map.

What Germany is Politically. The German Empire (209,000 sq. miles) dates only from 1871. The German Emperor, who is not Emperor of Germany, is the King of Prussia, the largest of the many independent States which make up the German Empire. With Prussia are united for political, military, and fiscal purposes the three kingdoms of Saxony, Bavaria,



THE RUHR COALFIELD

and Würtemburg, six grand duchies, many duchies and principalities, and the free cities of Lübeck, Hamburg, and Bremen. All these are independent in their internal relations, and all but the cities have hereditary rulers who rank among the royal houses of Europe.

What Germany is Physically. In a geographical sense South Germany consists of the Alpine foreland from Lake Constance to the valley of the Inn, a tributary of the Danube. In the west the frontier follows the crest of the Vosges, the valley of the Moselle for a short distance, and then runs roughly north. In the east it is more definitely physical, and is determined by the Böhmer Wald, Erz Gebirge, Sudetes, and the mountains beyond the Oder. Then it crosses the featureless plain in an irregular line trending considerably to the north-east. South Germany thus consists of the Central Highlands, and North Germany of the plain to which they slope.

Climate. We can deduce the general character of the German climate from our knowledge of the climate of Europe. In summer the isotherms will approximately follow the parallels of latitude, in winter they will cross them almost at right angles; that is to say, the south will be warmer than the north in the valleys in summer, but there will be very little difference in winter. Then the difference will be between the east with a severe winter, and the west with a mild one.

All this is true, but we want a little more detail. Take the January isotherm of 32° F., indicating frost. The Rhine basin lies outside it, and has mild winters and early springs. The isotherm enters Germany at the mouth of the Weser, and runs nearly due south through Munich. East of it the winters are long and severe, and spring late. The isotherms of 30°, 28°, 26° [see page 152], indicate increasing severity of frost, so that we can readily understand how much more intense the winter cold becomes as we go east. "In the Rhine district, when the swallows return and the almond and apricot blossoms are opening, snow is still lying in east Prussia, where the frost does not break up till the middle of March." Another consequence of the severe winters in the east is that the Baltic ports are closed by ice in winter, while those of the North Sea are open.

The summer climate of North Germany is very much that of the Thames basin, both having an average July temperature just over 62° F. South Germany is warmer. The July isotherm of 64° passes near Mainz, curves a little south, and oscillates round the parallel of 53°, south of which the summers are warm in the valleys, especially in those of the Rhine and its tributaries.

Products and Mineral Wealth. Magnificent forests cover the mountains of South Germany and parts of the northern plain, in all about one-quarter of the surface of the country. About one-half is under cultivation, the most fertile part being the Upper Rhine plain, the Garden of Germany. Here the vine comes to perfection, yielding famous wines. Its northern limit is about that of the warm summers, lat. 53°. In the east the winters are too severe for it. Much wheat is grown in the Rhine plain, but in most other parts rye is the chief cereal. The potato is grown in enormous quantities in North and Central Germany, and a coarse spirit, sold as brandy, is made from it. The sugar-beet is important in the same districts. Hops are grown chiefly in Bavaria, the beers of which are famous all over the world.

We have seen that Germany has an important coalfield, the Westphalian field, mainly in the Ruhr valley, at the northern margin of the Central Highlands. Other coalfields occur in similar positions: (1) the Saar field, on the Saar; (2) the Saxon field, north of the Erz Gebirge, drained by tributaries of the Elbe; and (3) the Silesian coalfield, between the Oder and the Vistula. Iron is found near most of them. Other minerals are abundant in the Central Highlands, one part of which is called the Erz Gebirge, or Ore Mountains.

The Rhine Provinces. From Basel to Karlsruhe the Rhine flows between the Grand Duchy of Baden on the west and the Imperial provinces of Alsace and Lorraine, annexed from France in 1871, on the west. From Karlsruhe to Mannheim the western bank

belongs to the Palatinate, politically part of Bavaria. From Mannheim to Mainz the river flows through the Grand Duchy of Hesse, and from Mainz to the Dutch frontier it is in Prussia. The kingdoms of Würtemberg and Bavaria, east of Baden, are partly in the Rhine basin and partly in that of the Danube.

The rest of Germany consists of the whole or part of the basins of the Ems, Weser, and Elbe, flowing to the North Sea, most of the basin of the Oder, and parts of those of the Vistula and Memel or Niemen, flowing to the Baltic. Before describing them a word must be said about the plain of North Germany, so different from the forested highlands of the South.

proached by bridges. They look out over a wide expanse of grass lands and cornfields, drained by innumerable canals. Seawards, the view is bounded by the dam, "beyond which extends a tract browsed only by sheep, and traversed by a network of salt sea runs."

The map of Germany east of the Elbe shows the character of the Baltic lakeland region. It is dotted with thousands of lakes, set among pine-woods, with irregular wooded heights—the Baltic Heights—rising above them.

The North German coast has been aptly compared to a tattered lace fringe, especially east of the Jutland peninsula. Here the rivers flow to fresh-water *haffen*, or lagoons, almost

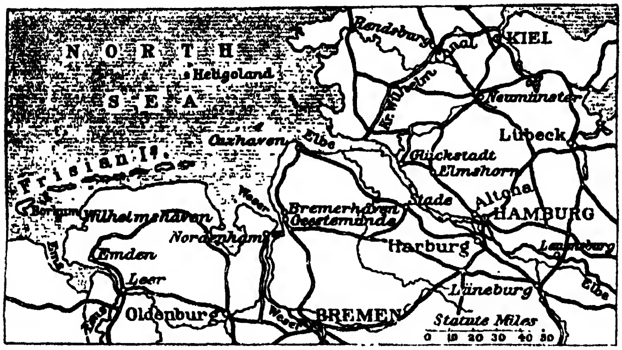
MAP OF THE GERMAN EMPIRE, SHOWING ITS RELATION TO ITS NEIGHBOURS

The North German Coast. North Germany consists of two belts. The south is a low plain, sloping from the Central Highlands; while the north is broken by wooded hills, forming the Baltic Heights. Much of both is moorland or *heide* (heath), poorly watered, and covered with heather or coarse grass. Only the sheep and the bee thrive, and villages are consequently few and population scanty. Along the coast in the west is a belt of marshy but fertile alluvial land, consisting of deep soil, without a stone, formed of the sediment brought down by the rivers. When drained it makes rich pastures. Population centres round any little height, on which are built churches and farmhouses, the latter with moats, and ap-

by broad sand bars. In the North Sea, where the strong tides carry the sediment out to sea, the rivers form estuaries.

The Ems and Weser Basins. The Ems rises in the Teutoburger Wald, an outlier of the Thuringian Highlands. It flows north through a marshy country to the North Sea, with Emden, its port, a naval station. Separated from it by the Teutoburger Wald is the Weser, formed by the union of the Fulda from the Rhön, and the Werra from Thuringia. It leaves the highlands by the gap known as the Westphalian Gate, affording a railway route. It flows across marshy country to the North Sea with the great port of Bremen at the head and Bremerhaven at the mouth of its estuary.

The naval station at Wilhelmshaven is on the Jade Bay just west of the Weser estuary. South of the Ems are the industrial towns of the Ruhr coalfield. Between the Ems and Weser is Bielefeld, the centre of the German linen manufacture. To the Weser flows the Aller, on tributaries of which are the fine old towns of Hanover, Hildesheim, and Brunswick. These



GERMANY'S NORTH SEA FRONT

tributaries drain the wooded Harz, rich in minerals, the highest point of which is the Brocken, famous in legend. Picturesque old towns, with fine timber houses, are built at the mouth of the Harz valleys, many engaged in mining. The free city and port of Bremen owes its prosperity to the deepening of the Weser. It has a large import and export trade, and manufactures many raw materials brought to its docks.

The Elbe Basin. The Elbe rises in the wild Riesen Gebirge, part of the Sudetes, and receives many tributaries in Bohemia. On the largest of these, the Moldau, is Prag, the capital of Bohemia. The Elbe enters Germany between the Sudetes and Erz Mountains, flowing through the district of Saxon Switzerland, with bottomless ravines and isolated flat-topped hills. At the north end of its gorge is Dresden, the capital of Saxony, with famous art treasures. The tributaries of the Elbe drain the Erz, Thuringian, and Harz Mountains. The largest is the Saale, from the Fichtel Gebirge, with Leipzig, the great printing and publishing city, on a tributary, and the salt town of Halle on the main stream. The Saale flows through a region rich in timber and sheep pastures, which supply the famous Saxony wool. This, with the minerals of the Erz, is manufactured on the Saxon coalfield, in the busy district round Chemnitz. Below its confluence with the Elbe, which has flowed through the potato and sugar-beet district, is Magdeburg, a great fortress, and the centre of the Elbe sugar manufacture. To the east the country is marshy and studded with lakes round Berlin, the capital of Prussia, on the Spree, which flows to a tributary of the Elbe. Berlin is a magnificent modern city, in the centre of the North German plain, with fine public buildings, a great university, as well as excellent canal and railway communication, and numerous industries.

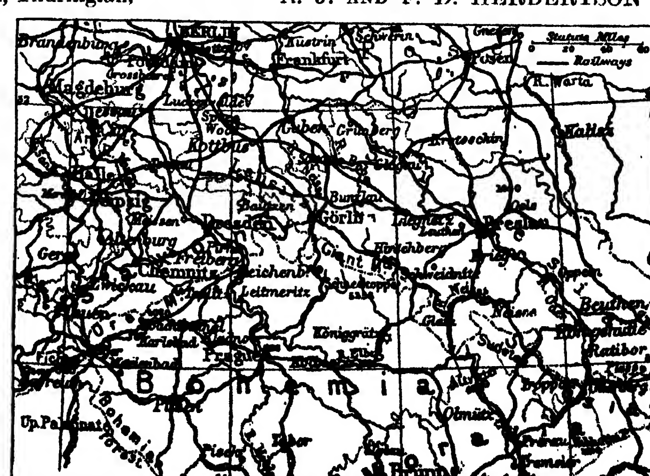
Hamburg. At the head of the Elbe estuary is the port and free city of Hamburg, the greatest commercial town in Germany, doing an immense trade with all parts of the world. Its imports are very varied. Its exports show the character of the Elbe basin. They include iron and machinery, textiles, woollens and worsteds, glass, cattle, cereals and timber. Altona, in Prussia, is now practically part of Hamburg. Cuxhaven is a port at the mouth of the estuary, belonging to Hamburg, opposite to which is the island of Heligoland, once British, and now strongly fortified.

The Kiel Canal and Oder Basin. Below Hamburg the Elbe estuary is connected by a ship canal with Kiel, giving a direct route from the North Sea to the Baltic Sea, without going round Denmark. Both Kiel, therefore, and Lübeck, a free city and port south of Kiel, are, in a sense, ports of the Elbe, to which indeed Lübeck is joined by the Trave Canal.

The Oder flows north-west, through a region producing rye, sugar-beet, and timber. Round its upper course are the Silesian coalfields, where Breslau manufactures wool, linen from local flax, and cotton. Sugar-making is important in and around Frankfurt-on-the-Oder. The Oder enters the Stettin Haff. Its port, Stettin, is connected by canal with Berlin, and builds great ships.

Only the lower courses of these rivers are German. Danzig is the port of the Vistula, and manufactures much of its produce. Among such industries are woollens, paper-making, shipbuilding (timber), distilling (cereals). Königsberg is the port of the short Pregel, and Memel is the port of the river Memel or Niemen.

A. J. AND F. D. HERBERTSON



INDUSTRIAL REGION OF SAXONY AND SILESIA

Dürer and Holbein. The Fêtes Galantes. Watteau, Boucher, and Greuze. Hidalgo and Inquisition. Velasquez and Goya.

ART IN WESTERN EUROPE

GERMAN painting of the fifteenth century has been admirably summed up by the famous art critic M. Reinach: "Italian art dreamed of beauty and realised its dream. Flemish art was in love with truth, and held the mirror up to Nature. German art rarely achieved either truth or beauty. But it succeeded in rendering, with a fidelity that was often brutal, the character of the German people immediately before and after the Reformation." Local schools were flourishing already in the fourteenth century in the various cities and districts, but comparatively few of the artists' names have been handed down to us, and modern research has had to be content in many cases with identifying the painters as "the master of such and such a picture."

The schools of Prague, Cologne, Augsburg, the Upper and the Lower Rhine, abound in such anonymous masters, who generally contented themselves with setting their angular figures, which in movement and expression often verge on caricature, against a flat golden background, without an attempt at landscape backgrounds, and without much concern for orderly composition. Yet there is an undeniably naïve charm in the sincerity of many of these works, though they have neither the beautiful colour, nor the tender sentiment, nor the delicate execution of the contemporary Flemish works.

Even Albrecht Dürer (A.D. 1471-1528), the greatest German master of all time, is no exception to the rule, and of pure beauty such as we have met in the works of his contemporaries in Italy but little is to be found in his pictures. He is intensely dramatic and serious, simple and direct, and combines to the highest degree all the qualities that are characteristic of the German Renaissance, a movement which was intellectual and moral rather than artistic. Few, if any, artists could rival Dürer in the rendering of textures, and this refers as much to his line engravings as to his paintings; few could invest every detail and accessory introduced in a picture with more interest; few there are that could depict a simple story with more homely, touching directness. Goethe justly wrote of his great fellow-countryman: "When we know Dürer thoroughly, we recognise that in truth, nobility, and even grace, his only equals are the greatest of the Italians."

The second of the great masters produced by Germany was Hans Holbein (1497-1543), the greatest painter of the Augsburg School, as Dürer had been the greatest of that of Nuremberg. Holbein is one of the few early Germans who is exempt from the charge of lacking the sense of beauty. He benefited by the lesson taught by the Italians as regards pictorial composition, and developed a noble free style which had none of the taint of German ugliness. At the same time he retained the typical German quality of careful, minute observation, tempered by sympathetic insight into character. His portrait drawings, of which a vast number are preserved at Windsor Castle—Holbein was Court painter to Henry VIII.—show his unrivalled sureness of touch and expressiveness of line.

Like most northerners, Holbein greatly loved to introduce a great variety of detail into his pictures, but he always knew how to subordinate it to the main theme, which it emphasises rather than detracts from. In such pictures as "The Ambassadors" at the National Gallery or the merchant "George Gyze" at the Berlin Gallery, all the accessories are fraught with meaning, but do not draw our interest from the personages depicted. And for perfect craftsmanship Holbein may be held up to every student as an example worthy of emulation.

In France the chief representative of the national school of painting in the fifteenth century was the illuminator Jean Fouquet, but the history of French painting may be said to begin with François Clouet (A.D. 1510–1572), better known as Janet, an artist considerably influenced by the Van Eycks, and one of the

world's greatest miniature painters. His portraits often bear a close resemblance to Holbein's. His contemporary, Jehan Cousin, owed nothing to foreign teaching and acquired great fame as a painter of glass.

Francis I., in A.D. 1531, called Primaticcio and a few other second-rate Italian painters to his country to decorate his castle at Fontainebleau, and this led to the founding of the school of Fontainebleau, from which issued a number of pseudo-Italian mannerists whose pretentious work only delayed the development of national French art. Only, the early seventeenth century brought forth a few native artists of decided originality, notably the brothers Le Nain, painters of homely scenes and of camp life, who had distinct affinity with the Dutchmen of the time, though their sombre colouring connects them with the Spanish school.

THE AMBASSADORS, BY HOLBEIN
National Gallery, London

The French Classicists. Nicolas Poussin (A.D. 1594-1665) studied in Rome, then considered the fountain-head of all art, and learnt the lessons taught by Raphael and Michelangelo, and even more by the antique. He was more classic than any of the Italian classicists, and his figure paintings are antique reliefs translated into terms of colour. His eclecticism debarred him from seeing life, movement, and emotion in Nature, which, in his pictures, are merely superficial adjuncts to classic poses. But he was a master of the "heroic" landscape, a landscape that is based on noble arrangement and linear perspective, and not on colour and atmosphere. Gaspard Poussin, his brother-in-law, was inspired by Nicolas in his landscapes, though the younger master was a little more concerned with light and air, and not so uncompromisingly severe. The same influence produced the style of Claude Lorrain (A.D. 1600-1682), who is considered in the article on landscape art, and who was an artistic progenitor of the great Turner.

Watteau and the "Rococo" Period. Another pupil of Poussin, Charles Lebrun (A.D. 1619-1690), became Court painter to Louis XIV., and ruled as a veritable autocrat over the art of his country, which degenerated into mere theatrical pathos. He was not only entrusted with all official commissions for paintings, but was made Director of the Gobelins Tapestry Works, and supplied designs for sculptors, cabinetmakers, and metal-workers. His paintings belong entirely to the literary order, and have little to do with art. The real national tradition was perpetuated to a certain extent by the portrait painters Mignard and Rigaud, and, above all, by Antoine Watteau (A.D. 1684-1721), the great painter of the "Fêtes galantes," the typical artist of the "Rococo" period. His arcadian scenes—French courtiers and amorous dames masquerading as harlequins and shepherdesses in delicious gardens—have not a trace of cold classicism, and hold up a faithful mirror to the idle, gallant life of eighteenth-century society. The life he depicts is essentially artificial, but there is nothing artificial in his style. With all their beauty of arrangement, his scenes do not appear to be constructed according to a formula, but have a convincing air of reality; and, above all, he is a painter who revels in the precious quality of the pigment and who allows air and atmosphere to enter into his landscapes. His followers, Lancret and Pater, degenerate into a coarse suggestiveness which is quite in accordance with the immorality of the Court of Louis XV.

Immorality in Art. This tendency reaches a climax in François Boucher (A.D. 1704-1770), the "Painter of the Graces," who is the typical child of a period of degeneracy, though his works, however objectionable they may appear from the moral point of view, have undeniable decorative charm and superficial beauty. His pupil, Fragonard (A.D. 1732-1806), is a brilliant delineator of the nude, an artist of great esprit, who connects the period of untrammelled lasciviousness with the downfall of the old régime brought about by the Revolution. Parallel with this current of art, which is essentially at the service of the Court, is another little stream which reflects the healthier life of the people. Chardin (A.D. 1699-1779) is a painter whose tendency is as decidedly moral and sermonising as Boucher and his school are immoral and seductive. And just as the latter are offshoots of the Italianising classicists, so Chardin is connected with Le Nain and with the Dutch small masters. Even more marked is the moral tendency of some of Greuze's genre pictures, though in other works he appears to cater for the sensuality of the ruling classes. But neither

FRENCH ROMANCE AND SPANISH REALISM

"THE MUSIC PARTY," BY WATTEAU, THE ROMANTIC PAINTER OF FRANCE

"THE SURRENDER OF BREDA," BY VELASQUEZ, THE MASTER PAINTER OF SPAIN

of the two was the founder of a school, and the Revolution directed the art of France into new channels.

French Sculpture. The progress of sculpture in France during these two centuries was very much on the same lines as that of painting. The master who dominates the seventeenth century, Pierre Puget (A.D. 1622–1694), did not receive official recognition, since he would not submit to the autocratic rule of Lebrun. His art was based on the study of the antique and of Michelangelo. The hold of the latter master over Puget appears most strongly in the "Milo of Crotona" at the Louvre. To the eighteenth century belongs Falconet, the author of the very academic equestrian statue of Peter the Great, at St. Petersburg; Clodion, a boudoir sculptor, who expressed in marble and terra-cotta what Boucher and Fragonard expressed in paint; Houdon, a brilliant modeller of portrait busts, and Pigalle, who continued to follow the antique with exaggerated elegance of form. His noblest work is the tomb of the Maréchal de Saxe, in Strasburg. What marks all French sculpture of this period is the striving after grace and elegance and decorative effect, which frequently results in limbs of exaggerated length and a certain dainty affectation, which is far from displeasing. The character of the period is certainly reflected in its sculpture as well as in its painting. But with the advent of the Italian Canova, at the turn of the century, all character was lost in a soulless, cold imitation of all that is merely formal in the antique. The fame of this uninspired marble-carver spread over the whole of Europe, and acted as an effective check to all individual expression. In every country his fatal example was emulated—in Denmark by Thorwaldsen, in England by Flaxman, in Germany by Danneker, and in France by numerous sculptors whose fame has been obliterated by the great men who followed in the second half of the last century.

THE LISTENING GIRL, BY GREUZE
Wallace Collection, London

Spanish Painting. The history of Spanish painting may be said to begin about the time when Granada was captured from the Moors, in A.D. 1492. In no other country was the individual expression so severely handicapped as in this country, where for centuries the Inquisition exercised a censorship which not only forbade the study of the nude and all other "worldliness," but interfered even in matters of detail. The slightest deviation from Scriptural truth or from Catholic dogma was treated as heresy. Thus in painting a "Crucifixion" every artist had to adhere strictly to the measurements of the cross, which had to be in the proportion of 15 ft. by 8 ft.; and the Italian sculptor Torrigiano, who was working in Spain, was actually imprisoned by the Inquisition for having, in a fit of passion, broken up a "Virgin and Child" wrought by his own hands!

Art Under a Shadow. This strict supervision by the Church, together with the serious, proud character of the Spanish race, produced an art of great sombreness and reserve, inspired by a passionate love of reality, an art which has dramatic intensity, boldness, and strength, but never sounds a note of gaiety and joy, and is rarely occupied with beauty and grace. It reflects the proud, hidalgic attitude to life, the grandeza and strict ceremonial of the silent Court, the iron rule of the Church and Inquisition. And through all the influences from abroad—from Flanders in the fifteenth century (the Gothic period), from Italy in the sixteenth century, and from France at the close of the glorious period which culminated with Velasquez — can be detected the sombre glow of these national traits.

Juan de Borgoña and Pedro Berreguete, both of whom worked in Castile at the end of the fifteenth century, were among the first to introduce Italian methods, which took firmer root when Charles V. and Philip II. induced a whole band of Italian painters to settle in Spain. Among the prominent Spanish masters of the early sixteenth century are Luis de Morales, Pedro Campaña, and Luis de Vargas, but their works, like those of innumerable other meritorious painters of the period, are practically unknown outside their native country.

The Rise of the Spanish School. What might be called the "historical" period of Spanish art rises with the school of Sevilla, towards the end of the sixteenth century. Pacheco, from whom Velasquez received his early training, was scarcely more than an able Italian mannerist; but Juan de las Roélas (A.D. 1558–1625) and Herrera the Elder (A.D. 1576–1656) introduced something of the sumptuousness of Venetian colouring into the sadness and dark shadows of the Spanish palette. Francisco Zurbaran (A.D. 1598–1662) was a painter of great emotional power, almost ecstatic in his dramatic intensity, with a sense of pleasing form and line.

An extraordinary genius, weird and passionate, was El Greco (1548–1614), who, in his endeavours to escape from the convention and imitation which fettered his precursors, arrived at a frenzied, extravagant style, with figures whose limbs

are twisted into extraordinary contortions and of inordinate length, seen in a patchy light that never was on sea or land. He was a restless spirit, but endowed with a noble sense of colour and with the gift of seeing the dreams of his almost insane imagination as a homogeneous whole.

Velasquez, King of Painters. With Velasquez (A.D. 1599–1660) we reach the apogee of Spanish art. He was not only the greatest master of his time, but opened a new vision to modern art, a vision in which the greatest painters of our own day find salvation. No one has ever more completely realised the truth of the saying that the greatest art is to conceal art. Painted with an astounding sureness and simplicity of means—his palette is said to have consisted of only four colours—his pictures produce an amazing effect of reality. His tone values are perfect, and there is a unity of vision which places before one just what could in real life be taken in by one glance, leaving out such detail as would detract from the general impression, and yet never slurring over anything that is really essential. In his portraits his sitters seem to live in the atmosphere in which they are placed, and their life is not only that of their body, but of the very soul. His psychological insight is the more marvellous, as he painted at a Court where everybody wore habitually a mask of cold dignity to conceal his real character. The realism of Velasquez is of a kind that never stoops to an indiscriminate recording of Nature's accidental blemishes. If his pictures appear to be the spontaneous result of direct observation, and have little in common with the studied arrangement of academic compositions, he is so perfect a master of selection that there is never a touch which would in the slightest degree disturb their quiet harmony and decorative spacing. [See illustration of painting by Velasquez on page 1747.]

THE HOLY FAMILY, BY MURILLO
National Gallery, London

Murillo and Ribera. The other name that is inscribed in letters of gold on the tablets of Spanish art is that of Murillo (A.D. 1617–1682), whose pictures have been aptly called the embodied expression of Spanish Catholicism. A charming colourist and accomplished draughtsman, he is wholly lacking in inspiration and depth of thought. He clothed the holy legends in the garments of his period, using the types of the people by whom he was daily surrounded, and thus translated the teaching of the Catholic Church into the vulgar tongue. One of his most familiar paintings is "The Holy Family" at the National Gallery, London. But fascinating as he is at times, he has little to add to the history of the artistic development of his country, or of the world at large. Contemporary with Velasquez and Murillo was Ribera (A.D. 1588–1656), who, trained by the Italian naturalists, became in his turn the paramount influence in the school of Naples. In spite of all that he derived from Italian sources, he always retained the ecstatic passion and the sombre shadows so characteristic of Spain. His favourite subjects were scenes of martyrdom and physical pain.

Goya the Satirist. With the death of Velasquez and Murillo, Spanish art collapsed as suddenly and completely as it had arisen under their dual star. A brief renaissance of the ancient splendour was, however, brought about by Goya (A.D. 1746–1828), an artist of immense versatility and great genius, though frequently hasty and slovenly in execution. In his best work he almost rivalled Velasquez—in fact, he is the one link that connects this great master with Manet and the later nineteenth century. He must be counted among the greatest etchers and lithographers of all times as he was one of the greatest satirists, who defied Government and Inquisition with his merciless exposure of the vice, ignorance, corruption, and immorality of his period.

P. G. KONODY

The Conscious and Unconscious Mind. Their Separate Systems. Work and Nourishment of the Nerves.

THE NERVOUS SYSTEM

THE nerves are not mere expressions or ideas; they are actual threads or fibres, stretching all over the body, just as the mass of telegraph and telephone wires runs everywhere over London. They connect the "brain-centres" with every part of the organism, and along them impulses are incessantly travelling to and from the brain. In order to understand the machinery by which the mind controls the body, it is necessary first of all to get an idea of the arrangement of the whole nervous system. We have already stated in an earlier section that this system may be subdivided into two—one under the control of the conscious mind and will, and the other under the sway of the unconscious part of the mind. They are called, respectively, the *Cerebro-Spinal* and *Sympathetic* systems.

Brain and Spinal Cord. The cerebro-spinal system comprehends, as its name implies, the brain and spinal cord and all the white nerves connected with them. This complicated machine forms the executive of the government, which consists of the supreme controlling power of the conscious mind, and transmits its will to the whole body. All commands issued by the brain are conveyed by the white cerebro-spinal nerves to every part of the body, and are carried out by the striped and voluntary muscles, to which the nerves are attached. This system has special control over the expenditure of life-force in all our actions and words—that is, over the animal life, or *kinetic energy*, of man.

Sympathetic System. The sympathetic system is different in every particular. Its centres are situated all along the front of the spine, the chief one being just behind the stomach and consisting of a large mass of nerve-cells. From these centres small greyish or *pink* nerves go to all the organs of the body, to all the blood-vessels, and to many other parts. It is also closely connected with the lower part of the brain and the spinal cord.

This system acts and carries on its ceaseless and most complicated operations without the conscious mind having any power to interfere or even to discover what is going on. Its actions appear at first sight to be mainly mechanical, but a longer study shows they are all controlled and set in motion by a central purposive power for the good of the body; this power is the unconscious mind. Although the sympathetic system appears to carry on all the complicated processes of life on self-acting principles, they are really under the control of the mind, which thus directs the actions of the *digestive, circulatory*, and *respiratory* systems; in short, those that produce and store up life-force rather than those that spend it, or over the vegetative or potential energy rather than over the animal side of the life of man. The sympathetic nerves are connected with the smooth, unstriped muscles.

Cerebro-spinal Nerves. The cerebro-spinal nerves themselves [73] are, as we have said, the cords or electric wires that stretch from the brain and spinal cord to every part of the body. They are *white threads* of microscopic size collected into bundles or bands called nerve trunks, the largest, the sciatic nerve, being three-quarters of an inch broad in the thigh [74], and the smallest, almost invisible, like the finest thread. If we examine one of these nerve trunks we find it surrounded by a sheath of connective tissue, and consisting of bundles of smaller nerve bundles and blood-vessels and lymphatic fibres. In the nerve trunk these bundles are not twisted, but lie straight side by side. The bundles can be subdivided still further, until we get to the single *nerve fibre*.

Every nerve fibre runs (just like a telephone wire) straight from its starting point to its end and without branching or uniting with others. The trunks branch and divide and join, but the undivided fibres never do so during their course. One thirty-sixth part of the whole weight of the body is nerve substance.

Structure of a Cerebro-spinal Nerve. The medullated or cerebro-spinal nerves of which we speak vary in size from $\frac{1}{12000}$ to $\frac{1}{1500}$ of an inch in diameter, and consist of three parts.

First there is a protective sheath like the *hemp covering* of an underground electric wire; then a fine white substance sheathing the nerve all round, like the *sheath of guttapercha* which insulates (or prevents any of the electricity escaping from) the electric wire in the centre; and lastly not a *wire*, but a tube full of fluid, along which, it is believed, the impulse travels from the brain.

The outer covering is called the primitive sheath or the *neurilemma*, and is a delicate membrane with constrictions every one-fifth of an inch and occasional corpuscles between. The sheathing or insulating substance is called the medullary sheath, medulla, or *white substance of Schwann*; it gives these nerves their white appearance, and it also affords rich food for the nerve within, on account of the large amount of fat it contains in an emulsion, the globules of which refract the light, and thus account for its colour. It is semi fluid and like chyle.

The tube in the centre is called the *axis cylinder*, and is the essential part along which all impulses travel. It occupies a quarter of the diameter of the nerve, and in a cut specimen often projects like the wick of a candle. It consists of very fine fibrils.

As the nerve fibre approaches its termination at either end, it first loses its central coat, the medullary sheath, and then the outer one, the primitive sheath, the naked axis cylinder breaking up into fibres at its attachment.

Structure of a Sympathetic Nerve. In sympathetic nerves the non-medullated nerve fibres are also gathered up into trunks and bundles, and consist of axis cylinder and

78. DIAGRAM OF THE NERVES OF THE BODY

1. Cerebrum. 2. Cerebellum. 3. Medulla. 4. Cervical ves. 5. Spinal cord. 6. Dorsal nerves. 7. Phrenic erve. 8. Brachial plexus. 9. Nerves to the palmar urface of the hand. 10. Nerves to the dorsal surface of he hand. 11. Intercostal nerves. 12. Lumbar plexus. 13. Great sciatic nerve. 14. Cauda equina. 15. Nerves to the lower extremities.

itive sheath (neurilemma) only; they vary in size from $\frac{1}{8000}$ to $\frac{1}{5000}$ of an inch. The absence of the medulla coat, the white substance of Schwann, gives these a greyish or pinkish colour. They differ further from the medullated in branching frequently and forming networks.

In the brain and spinal cord we get innumerable naked axis cylinders without any sheath at all. The cells from which these fibres spring occur generally in clusters called ganglia, and may be of any shape. They always have a nucleus, and have one or more branching processes or poles; hence they are called unipolar, bipolar, multipolar, or, if without bundles, apolar. One of these processes, which is probably prolonged into a nerve, is always unbranched, and is called the axis cylinder process.

These cells have no distinct limiting membrane, and consist of granular protoplasm with a large nucleus. They are often angular and triangular in shape, and able to move when living.

Four Kinds of Nerve Cells. We may recognise four varieties of these cells.

1. Those with no white substance of Schwann or covering of neurilemma, as in the brain, and connected with the naked axis cylinder nerves.
2. Those with no white substance of Schwann, but with neurilemma, as in the sympathetic ganglia, and connected with the non-medullated sympathetic nerves.
3. Those with the white substance of Schwann and no neurilemma, as in the brain, and connected with nerves of similar construction, which form the white substance of the brain.
4. Those with both the white substance and neurilemma, as in the ganglia of the spinal cord, connected with ordinary medullated nerves.

Where the Cells are Found. Nerve cells are found in the brain and spinal cord, in ganglia, and at nerve endings in the tissues. The spinal cells are generally unipolar, and are embedded in a finely granular ground substance (neuroglia), and have no neurilemma. In the ganglia of the posterior root of the spinal nerves the nerve cells have a sheath of neurilemma and a short process which branches like a T.

Nerve matter has a specific gravity of 1031. It is 70 to 80 parts water and 20 to 30 parts solids.

The solids are composed as follow:

Phosphoric acid	9·0
Phosphate of potash	55·0
Phosphate of sodium	23·0
Phosphate of iron..	1·0
Phosphate of calcium	2·0
Phosphate of magnesium	3·0
Chloride of sodium	5·0
Sulphate of potash	1·5
Sulphate of silica	·5
	100·0

These elements are combined to form characteristic compounds, of which the chief are cerebrin and lecithin. The very large proportion of phosphorus will be noted.

Nerves are not elastic and do not retract when cut, but they can be stretched without rupture.

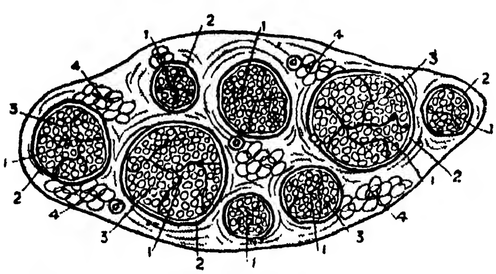
We know little of the active life of nerves. It has not been proved that they absorb oxygen and give out carbonic acid gas. They are very excitable, as can be shown in various ways.

Stimulation of Nerves. *Mechanical stimuli* produce at first either sensation or movement. If continued a long time the sensation gets lost and the movement ceases. When a leg sleeps the temporary paralysis is believed to be due to the continued pressure of the under-knee into the hollow of the upper one, when the legs are crossed, so that the axis cylinder gets squeezed. Heat and cold stimulate a nerve,

unless they are excessive, when they paralyse it. Some chemicals also, such as acids, alkalis, alcohol, ether, chloroform, at first stimulate and then paralyse. Electrical stimuli act most on a nerve at the moment of application (making) or cessation (breaking). Single shocks rapidly applied so excite the motor nerves that tetanus is produced in the muscle. It is frequently found that the further a motor nerve is from the central system, and the nearer a sensory nerve is to it, the greater the effect produced by electrical stimulus.

The nature of the *normal stimulus* is entirely unknown. It travels from or to the brain, giving rise to motion, or sensation, and moves more slowly than stimulus induced by electricity.

Nutrition of Nerves. The nutrition of nerves depends to a great extent on the nerve cells, and their excitability depends on their nutrition. Nerve fibre gets exhausted more slowly than muscular fibre, and recovers more slowly. Continued inaction of a nerve diminishes its excitability. If any nerve be severed, degeneration sets in, and the irritation decreases from the cut end upwards. Repair takes place when the severed ends are brought together from the sound parts in the reverse direction. The effects of cutting a spinal nerve are very instructive. (1) If the *whole nerve* be divided after the junction of the anterior and posterior roots, complete peripheral degeneration of both sensory and motor fibres sets in, the central part remaining unaltered. (2) If the *anterior root* alone be divided, only the motor peripheral fibres connected with it degenerate, the rest of the nerve remaining sound. (3) If the *posterior root* be divided before the ganglion, the nerve only perishes between the cut and the spinal cord. (4) If it be divided both before and after the ganglion, the degeneration spreads both ways. These experiments show that the centre of nutrition of anterior nerves lies in the spinal cord; of the posterior, in the ganglion.



74. TRANSVERSE SECTION OF SCIATIC NERVE

1. Bundles of nerves. 2. Neurilemma round them.
3. Medullated nerve fibres (axis cylinder in middle).
4. Fat.

Electric Nerve Currents. There are small currents of natural electricity in healthy nerve tissue as in muscle. Natural nerve currents in sensory nerves travel about 140 ft., and in motor 111 ft., per second. Electricity and light travel about 200,000 miles per second. Sensory and motor nerves will conduct impulses indifferently either way. The direction of the current is determined by the source of the impulse, which in sensory nerves is peripheral; in motor, central.

As we have seen, the effect of stimulation of a nerve depends on the manner of its ending. Theoretically, a nerve can carry a current either way, but practically it can only be used in the body to convey a current in one direction, because of the nerve ending. The passing of a nerve current is therefore shown in an afferent or sensory nerve by pain or other sensation; in an efferent or motor nerve by muscular twitching or movement. Sensation is the result of organic change in a central nerve cell, just as movement is the result of organic change in a muscle cell. The terms sensory and motor are not, however, quite accurate.

Another Classification of Nerve Fibres. Nerve fibres are better divided into (1) afferent or centripetal; (2) efferent or centrifugal; and (3) intercentral—*i.e.*, between the two nerve cells.

Efferent nerves carry orders from the brain and spinal cord to all the muscles of the body. When it is remembered that each muscular fibre has a nerve attached to it, the great number of them is apparent. The longest nerve fibre is, of course, that which reaches from the brain to the big toe. These nerves end in the muscular fibre in a sort of flat plate, which is fastened on to it; it has the power, by means of its current, of suddenly causing the fibre—and hence the whole muscle—to *shorten and thicken.* The nerves leave the brain and spinal cord from the front part, and run in bundles with the posterior sensory nerves. The nerves all commence or end in some brain cell in the grey matter.

Afferent nerves convey impressions from every part of the surface of the body, and from every part of its interior to the brain, making it acquainted exactly with all that is going on. Every single fibre of the countless millions starts from beneath the skin, or from some part or organ, and runs, joined with others in bundles, to the back of the brain or spinal cord, which it enters, and then terminates in one of the central nerve cells. These nerves convey all the intelligence to the brain of what goes on inside and outside the body. They convey sensations of heat and cold, of pain and pleasure, of hardness and softness, smoothness and roughness, as well as sensations of taste and smell. In the ear and eye they are connected with elaborate instruments to convey light and sound.

Sympathetic Nervous System. We will now leave the cerebro-spinal system, and turn to that with which the conscious mind and will have nothing whatever to do—the *sympathetic nervous system.* We have already seen that it lies all along the front of the backbone. It is also connected in very many parts with the spinal system, so that some of our actions are partly voluntary and partly sympathetic. Our mind can recall actions which make us blush for shame, but the blush itself is

due to the enlargement of the capillaries by the sympathetic nerves.

The sympathetic nerves have, speaking generally, the same functions as the cerebro-spinal nerves, being both afferent and efferent. That they conduct afferent impressions, not generally felt as sensations, is clear in disease when we experience sensation in parts that are ordinarily without any feeling whatever, and are supplied by sympathetic nerves. Only intense impressions or sensations in disease are thus conducted on to the conscious brain. The sympathetic nerves are pink or grey, because they consist only of two parts, the outer fibrous coat and the inner tube of nerve matter. Many of the internal organs have sympathetic systems of their own. The heart has no less than three sympathetic nerve centres in it, in virtue of which it beats, and can go on beating, even when removed from the body, for many hours if fed with blood and kept warm. The beating is, however, controlled in two ways—from the medulla, by means of the pneumogastric nerve that slows it; and from the main sympathetic system, by a nerve that accelerates it. Hence, in indigestion, etc., when the sympathetic nerve is irritated, the heart's beat is quickened and it palpitates or beats very fast; whereas, if the nerve in the neck be compressed or irritated, the heart is slowed, and might be stopped altogether.

Nerves Given Off by the Brain. Nerves are arranged in pairs, right and left, all over the body—that is, there are always two alike. The brain itself gives off twelve pairs of nerves, as follows:

One pair of sensory nerves from the nose, conveying smell, called the First Nerve.

One pair of sensory nerves from the eye, conveying light, the Second Nerve.

One pair of sensory nerves from the ears, conveying hearing, the Third Nerve.

One pair of sensory nerves from the tongue, conveying taste, the Fourth.

One pair of sensory nerves from the face and teeth, principally conveying feeling, the Fifth.

Three pairs of motor nerves, controlling movement of the eyeballs, the Sixth, Seventh, and Eighth.

One pair of motor nerves, controlling movement of the face, the Ninth.

One pair of motor nerves, controlling movement of the tongue, the Tenth.

One pair of motor nerves, controlling movement of the neck, the Eleventh; and

One pair of motor and sensory nerves running to the larynx, lungs, heart, stomach, and liver (the Twelfth), and hence called the *pneumogastric* or the lung and stomach nerves.

75. A HIGHLY DEVELOPED NERVE CELL SHOWING THE NUCLEUS

Magnified 2000 times. In the centre is the clear, unstained nucleus, containing a round stained body termed the nucleolus.

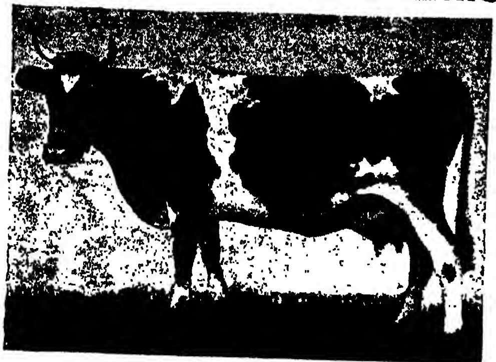
Large nerves supply the arms with motion and sensation. They leave the spinal cord in the neck, and passing out between the vertebræ, unite in a large cord that runs under the collar-bone, and there divides into five large nerves.

All down the back a pair of nerves is given off from the spinal cord about every inch, and runs along inside each pair of ribs. Lower down in the abdomen they run in the muscular wall. At the base of the spine two great cords are given off; these soon divide again, one on each side, one for the back and the other for the front of each leg. The posterior nerve is called the sciatic, and when it is inflamed we are said to have sciatica, which is very painful.

The nerves, like the blood-vessels, are well protected from violence by running along the inside or least exposed part of the limbs.

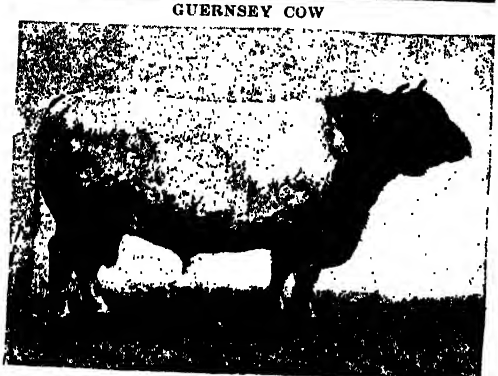
A. T. SCHOFIELD

SOME CHARACTERISTIC BRITISH CATTLE



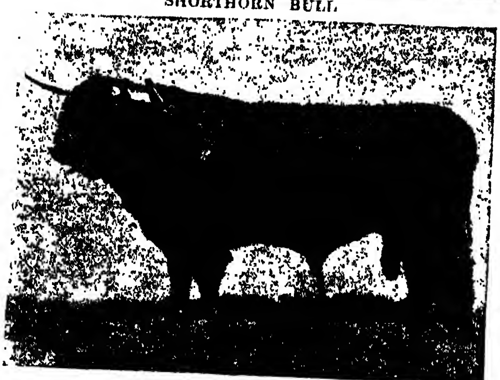
GUERNSEY COW

JERSEY COW



SHORTHORN BULL

HEREFORD BULL



HIGHLAND BULL

LONGHORN HEIFER

RED POLL BULL

AYRSHIRE COW

The Most Suitable Breeds for Beef and Milking: Mendel's Law and its Application in Stock Raising.

BRITISH BREEDS OF CATTLE

The ox (*Bos taurus*) has been domesticated from the period of the later Stone Age, and it undoubtedly had a tremendous civilising effect in inducing men to settle down from a savage state.

The Economic Value of Cattle. Economically, the value of cattle is literally inestimable. Not only is beef the principal article of food in many countries, but in recent years a number of industries have sprung up, such as the tinned beef industry in the United States and elsewhere, for preserving and making extracts of the flesh of the ox for human consumption. Milk, butter, and cheese are necessaries of life, and dairying has developed to such an extent that in the United Kingdom it is regarded as the farmers' mainstay during periods of depression in the agricultural industry.

In addition to milk and beef, practically every part of the carcase of the ox can be put to some useful purpose: thus the hide goes to the tanner; the horns, bones, and hoofs are used for the manufacture of knife-handles and glue; the refuse, together with the blood, is made into manure; and the hair is also used in making plaster.

Nor is the use of the ox as a beast of draught by any means unknown even in England. At the present time teams of oxen may be seen at work on certain farms in the Cotswold district of Gloucestershire, and teams of working bullocks are regularly employed on Lord Bathurst's home farm at Cirencester.

Sources of British Cattle. All evidence goes to show that the aurochs (*Bos primigenus*) was the ancestor of all the long-horned, short-horned, and hornless breeds of cattle in Europe. At the time of the Roman occupation the Celtic shorthorn (*Bos longifrons*) was the only domesticated breed of cattle in Britain. Subsequently cattle belonging to the urus family were introduced by the Teutonic invaders at various periods and crossed with the native cattle. We may thus take it that the present breeds are descendants of these two races blended at different times. As the conquering tribes with their cattle settled first in the east or south of England, the Celtic shorthorns were gradually pushed into the mountainous districts of the north and west, and their descendants may now be seen in the West Highland, Welsh, Kerry, and Devon and Sussex breeds. The gradual development of the special points and characteristics of existing breeds have therefore been largely influenced by climate and environment.

Principles of Breeding. Great improvements have been made in the breeds of live-stock in the United Kingdom during the last hundred years, and many advances have taken place in the art of breeding. This has been due to the instinctive knowledge of the characters of first-class stock possessed by breeders following on the principles set forth and practised by Robert Bakewell (1725–95), of Dishley, in Leicestershire. The teachings of modern science have also been of marked assistance to the breeder; and there is little doubt that experiment and research, carried out on proper lines, will play an important part in the future in developing and furthering the interests of the breeding industry.

Although no hard and fast rules can be laid down for the guidance of the breeder so that he can produce stock "to order" of any particular type required, still there are certain laws or principles applicable to all classes of domesticated stock which may be relied on to a large extent, and which are worth discussing briefly.

Heredity and Variation. The first of these principles may be stated in the phrase "like begets like," and this is accountable for what we know as "family likeness." That is to say, the offspring of two parents will probably show some of the characteristics of each of them; or, in other words, be of an intermediate type, although this is not always the case. This is frequently seen in human beings. In the case of animals, therefore, within certain limits, whatever peculiarities the sire and dam possess may be looked for in the offspring; slight variations, however, will always be noticeable.

In the case of domesticated animals there is no struggle for existence, and the "artificial selection" of the breeder takes the place of "natural selection." In these circumstances the owner retains those animals for breeding which show desirable characteristics and conform to the type he wishes to establish. Such methods were followed in most of the improved breeds during the nineteenth century, and the coarser points and slow-growing habits were got rid of, while desirable qualities, such as milking, flesh-producing, and wool-bearing powers, were developed, although in some cases at the cost of the constitution of the animals.

One property that has been specially developed is early maturity, which causes animals to be ready for market at an earlier age than formerly. Thus bullocks are now fattened at the age of from twenty to thirty-six months, instead of at from four to seven years old.

In-breeding. It is possible to hasten the process of development by selection and breeding from closely related animals. This helps to fix a certain type, but when carried too far results in great loss of constitutional vigour, combined with sterility and loss of size. In-

breeding was made use of by the founders of the present breeds to fix a definite type, but it must not be pressed beyond a certain point.

Crossing. When the sire and dam of two distinct breeds are crossed, the offspring generally shows the good points of both. Some of the best fattening stock is produced in this way. Thus a white shorthorn bull crossed with a Galloway cow produces the "blue-grey" so much sought after for feeding purposes in the north of England.

For this purpose it is not wise to go beyond a first cross, however, as undesirable characteristics then begin to make their appearance.

Prepotency. Animals that have been bred to a certain type for a number of generations have a great power of stamping their qualities on stock that has not been so well bred. This power of prepotency, as it is called, is often made use of for improving a herd of ordinary cows by using a pedigree bull, and much loss has occurred in the past through dairymen begrudging a few extra pounds when purchasing a bull for the use of their herd. Prepotency may also be made use of in the breeding of beef animals, as when a shorthorn bull is mated with cows of the slower maturing breeds, as Kerry, Ayrshire, or Galloway.

Reversion. In improved breeds that have been bred on definite lines for a number of years the points are fixed, and they are capable of transmitting them. Occasionally, however, some characteristic not possessed by the immediate parents appears in the offspring, as the sudden appearance of horns in the calf of a polled breed, or hair and a dark colour in the fleece of a sheep of a good flock. This appearance of some point not possessed by the parents is called "reversion," "atavism," or "throwing back" to some characteristic of the original ancestors of the breed. Crossing always has a tendency to encourage this.

Application of Mendel's Law. Before leaving the subject of breeding, we must consider the practical application of Mendel's laws of inheritance, which, since their rediscovery, have been tested both with plants and animals. Gregor Johann Mendel (1822–84) carried out his investigations in cross-breeding, using plants for the purpose of his experiments, about the middle of the nineteenth century, and his theories explaining his results were published in 1865. Little attention, however, was paid to the matter at the time, and it was not till later that the value of his work was recognised, and numerous trials were instituted to test his statements. The most important of these experiments, carried out by Professor R. H. Biffen at Cambridge on the cross-breeding of wheats, confirmed Mendel's views; and much light has been thrown on many hitherto somewhat obscure points connected with crossing.

The old idea with regard to crossing different varieties of plants was that the act of crossing produced a large amount of variation or sporting in the offspring, and that a fixed type could only then be obtained in rather haphazard fashion by a tedious process of selection. Professor Biffen, working on Mendelian lines, however, has clearly shown that crossing does not give rise to miscellaneous progeny, but that the offspring of the second and subsequent generations are produced in a definite order and in a fixed ratio.

In estimating results it is necessary to take into consideration the potency of the pairs of unit-characters of the two parents and the extent to which these are capable of being transmitted to the progeny in the second and following generations. Accordingly, while some pairs of unit-characters have equal potency and will be evenly divided in the offspring, in other pairs one unit-character will hold mastery over and tend to obscure the other. In this latter case the first unit character is said to be "dominant" over the second, and the second is said to be "recessive" to the first.

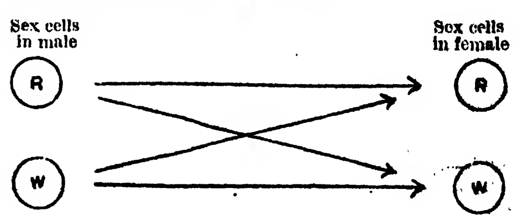
Results in the Colour of Cattle. As equally interesting results have been obtained with animals as with plants in testing the law, we will take the case of the colour in cattle to illustrate the point. Thus, if pure red and pure white cattle are bred together, the following results may be expected in the colour of the offspring:

	Red		White		
First generation			Roan (hybrid)		
Second generation	Red (25 per cent.)		Roan (50 per cent.)		White (25 per cent.)
Third generation	Red (pure bred Reds)	Red (25 per cent. pure)	Roan (50 per cent. hybrid)	White (25 per cent. pure)	White (pure bred Whites)

From this we see that in the case where a red and a white parent, whose colours are of equal potency, are mated, the offspring will be a roan, or, in other words, a hybrid blending the two pure colours. If two of the roans are bred together, some of the calves will be red, others roan and others white, in proportion of 1 : 2 : 1, or red 25 per cent., roan 50 per cent., and white 25 per cent.

If, then, the reds are bred together, they will produce pure-bred reds; the whites likewise bred together will give rise to pure-bred whites; but the roans of the second generation, on the other hand, if mated, will give reds, roans, and whites in the proportion of 1 : 2 : 1.

The Mendelian Explanation of the Results. The Mendelian explanation of these results is that the hybrid carries from the beginning the sex-cells or determinants which will decide the colour and other characteristics in a pure and not a blended condition. The determinants are produced in approximately equal proportions, and some of these carry the red character and others the white. The chances of combination when roan crosses are bred together will then be as represented in the following diagram, supposing R to represent the character for redness and W for whiteness:



The combinations possible, therefore, are R R producing red animals; W W producing white animals; R W, W R giving rise to roan animals intermediate in colour. No other combinations except these four are possible, a fact which accounts for the ratio 1 : 2 : 1, noticed above.

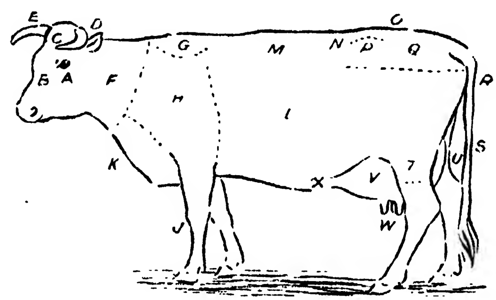
We will now take a more complex case, where one colour, as black, is dominant over another, as

red. If, then, pure black and pure red cattle are bred together, the results as set out in the following table may be expected:

		Black			Red	
First generation			Black (hybrid)			
Second generation	Black (pure)	Black (hybrid)	Black (hybrid)	Red (pure)		
Third generation	Black (pure bred Blacks)	Black (pure)	Black (hybrid)	Black (hybrid)	Red (pure)	Red (pure bred Reds)

Here the hybrids of the first generation will be black, following the colour of the dominant parent, although certain of the sex-cells will still retain their character for redness, but in a hidden form. If these hybrids are mated, the dominant colour (black) will appear in the offspring in the proportion of three to one, while one-fourth of the calves will be of the recessive colour (red). Only two of the blacks—one fourth of total offspring—however, is pure, and the other two—or one half of total offspring—are really hybrids, although assuming the dominant colour externally. The pure blacks and reds of this second generation, if bred together, will throw blacks and reds true to type respectively; but the hybrid blacks, if mated, will again produce blacks and reds in the proportion of three to one, only one of the former, however, being pure black.

These examples, taking colour as the character to be experimented with, will serve to explain the main principles of the law, but, as may be imagined, where more than one pair of characters are present in the parents the transmission of these to the progeny is of a more complicated character, and leaves a wide field for investigation and research. Experimental biologists and agriculturalists are today combining in the study of this question, and their results are expected to be of the greatest value to stock-breeders. [See LIFE AND MIND].



THE POINTS OF THE COW

a, Eye; *b*, face; *c*, forehead; *d*, ear; *e*, horn; *f*, neck; *g*, top of shoulder; *h*, shoulder; *j*, knee; *k*, dewlap; *l*, ribs; *m*, back; *n*, loin; *o*, rump; *p*, hip; *q*, quarters; *r*, tail; *s*, switch; *t*, thigh; *u*, hock; *v*, udder; *w*, teats; *x*, abdomen and milk vein

Crossing of Suffolk and Dorset Horned Sheep. One of the most interesting experiments on Mendelian lines with animals is that which has been conducted at Cambridge by Professor Wood on the inheritance of the face-colour and horns in sheep. The breeds selected for the trial were Suffolks and Dorsets, the former having black faces and no horns, the latter white faces and horns in both sexes. A number of Suffolk ewes crossed with a Dorset ram produced lambs all of which had speckled faces. The cross was also made in the opposite direction with a similar result. The hybrid lambs of the first cross must therefore be described as intermediate as far as facial colour is concerned. The following table will show the results obtained in the subsequent progeny of the first and second generations—results which are on a par with those obtained by crossing lax and dense-eared wheats:

	Suffolk (black faces, no horns)		Dorset (white faces, horns in both sexes)
First generation	(Speckled faces.	Intermediate Males horned.	Females hornless)
Second generation	White-faced (horned or hornless)	Speckled-faced (horned or hornless)	Black-faced (horned or hornless)

It will be seen that, when the hybrids of the first cross were bred from, lambs with white, speckled, and black faces were secured. It thus appears that the result of mating the hybrids is to produce once again the characters of the parents, together with a further type of hybrid.

Taking the question of horns into consideration, we find that the males are horned and the females hornless. With the second cross, the black or white or speckled individuals may be horned or hornless. The point to be noted, therefore, is that if it were desired to establish a pure breed from the offspring of this second cross there would probably be no difficulty in the matter, as the white and black faces would, without doubt, at once breed true to these characters, and attention would only have to be directed to the horns.

How far the results of these tests may be applicable to cattle and other classes of farm-stock remains to be seen, but indications point to far-reaching effects; and the application of the principles thus demonstrated is likely to play a very important part in developing stock-breeding during the next few decades.

Breeds of Cattle. As has already been stated, British breeds of cattle are probably the descendants of the aurochs and the Celtic shorthorn, which have been blended in various ways since the time of the Roman invasion. The gradual development of the characters and points of the various breeds as we now know them has been largely influenced by the climate, soil, environment, and other special conditions. In deciding on a form of classification, therefore, one based on the locality in which the breeds are found seems to be more intelligible than any other.

ENGLISH BREEDS.

General Purpose Breeds

Shorthorn | Red Poll | South Devon

Beef Breeds

Hereford | North Devon | Sussex | Longhorn

SCOTTISH BREEDS

Ayrshire | Aberdeen-Angus | Zetland or Shetland

West Highland | Galloway | Cattle

WELSH BREED

Welsh Black

CHANNEL ISLANDS BREEDS

Jersey | Guernsey

IRISH BREEDS

Kerry | Dexter Kerry

English Breeds : The Shorthorn. This is the most important and most widely distributed of all British breeds. Not only does it provide the usual type of cattle common in the country, but, owing to its excellent qualities and adaptability to climate, it has found its way all over the British colonies, as well as the United States and South America. Indeed, it is held in so much esteem that foreign buyers are continually taking the best of our British-bred stock to improve their herds and cross with their native cattle.

If a visit be paid to one of the principal markets in the United Kingdom, it will be seen that, except in a few localities, the majority of the cattle exposed for sale are of the non-pedigree shorthorn type; and, in fact, it may be said that the shorthorns in number equal, if not exceed, all the other breeds in the British Isles put together. When we consider that the shorthorn is the general class of animal found on the farms all over England, we understand the necessity for its being bred on general utility lines, so that when it has finished its period of milking it may be capable of being turned into a good carcase of beef, thus causing little loss to its owner. Under these circumstances, breeders who endeavour to convert the shorthorn into a beef or milk animal only are working on the wrong lines; and it cannot be too strongly pointed out that the animal required is a dual-purpose cow which can profitably go to the butcher when its services are no longer required in the dairy.

The Characteristics of Good Shorthorns. The colours most favoured in the short horn are deep roans and reds of various shades. Reds and whites and also pure whites appear, but there is a prejudice against the latter colour. The nose should be flesh-coloured; and a black nose is objectionable, as it is considered to denote impurity.

The horns should be short and blunt, of a creamy colour, and free from black tips. Very little seems to be known of the early history of the breed, except that it originated in the north-east of England, and at one time a strain of Dutch blood was probably introduced.

Towards the end of the eighteenth century the brothers Charles and Robert Colling began their improvement of the breed as it then existed by a process of in-breeding, and one of their bulls, called "Hubback," may be looked upon as the father of the present improved shorthorn.

Two well-known breeders, Thomas Bates, of Kirklevington, and Thomas Booth, of Killerby, then came on the scene, and the two great branches of the shorthorn breed are named after them respectively. The descendants of the Bates cattle are noted for their style, quality, and deep milking propensities; those of the Booth strain, on the other hand, are famous for their great girth, deep carcases, and beef-producing power.

Of recent years a Scottish strain of shorthorns has come much to the front remarkable for their constitution, massive frames, and early maturity. These are sometimes spoken of as Aberdeenshire shorthorns, and are associated with the name of Amos Cruickshank, the original founder of the strain. The type of shorthorn in demand, especially with foreign buyers, is one of Scottish descent blended with a certain amount of Bates blood for the object of maintaining quality.

Lincoln Red Shorthorn. A special strain of red shorthorns has been established in Lincolnshire, and a herd-book has been started in order to develop their milking qualities by selection. They are large-framed animals, rather coarse in the bone, but well suited to the better classes of soil.

Red Poll. This small, compact, modern breed without horns is found in Norfolk and Suffolk. The colour is red, with a white tip to the tail. It is specially noted for its combined qualities of beef and milk, and originated in a cross between a local breed of Norfolk horned cattle and the old Suffolk polled cattle, which bore a very high reputation for milking properties.

South Devon or South Hams. The home of this breed is in South Devon and Cornwall. They are large-framed and big-boned animals, rather inclined to be coarse, but with good udders. The South Devon is of a yellowish tint, being distinctly lighter in colour than the neatly built North Devon, and the type reminds one strongly of the Guernsey.

It seems probable that the two Devons were descended originally from a common stock, but that climate and local conditions have developed the southern branch on its modern lines as a dual-purpose cow. They are heavy milkers, and are also capable of yielding a large carcase of beef. For these reasons they are becoming very popular, and are beginning to be exported abroad.

Hereford. The Hereford is one of the best-known of British breeds, and is widely distributed in America and Australia. As far as points are concerned, the colour is light to dark red, with white markings along the spine, face, throat, belly, udder, and tip of tail. The muzzle is flesh-coloured, and the horns are of medium length, white, with a slight tinge of yellow. The Hereford is an excellent grazing bullock, and in this capacity large numbers may be seen in the summer on the rich feeding pastures of the English Midlands. They are indifferent as milkers, and the calves are usually allowed to run with the dams. However, an effort is being made to develop a dairy type. In the past the breed produced good working oxen, but only in rare instances are they now used for this purpose.

North Devon This important breed is found in Devon and parts of Somerset and Dorset, and the cattle are sometimes spoken of as the "Rubies of the West." Their general neatness and symmetry of form have earned for them the name of "Southdown" among cattle. The carcase is smaller and more compact than in the case of the Hereford or Sussex, and is much liked by butchers. There are two distinct types of North Devon—"the true North Devon," which is of a deep red, with white hairs on the udder and tip of the tail; the skin orange-yellow; creamy white horns, black tipped, and curling upwards in the case of the cow; and the "Somerset type" of Devon, lighter in colour and coarser in carcase and horn. As in the case of the Hereford, this breed was much used at one time for purposes of cultivating the soil.

Sussex. These cattle resemble the Devons in many respects, and it seems probable that they are also the more or less direct descendants of the Celtic shorthorns. The colour is dark red, duskier than in the North Devons, and they are also larger in frame and somewhat coarser than the latter breed. The Sussex was much improved during the nineteenth century, and its early maturing properties were enhanced. Fine specimens of bullocks of this breed are grazed during the summer on Pevensey Marshes, between Eastbourne and Hastings, and, with their long, strong horns, are a well-known feature in that neighbourhood. The beef is of first-

rate quality when the animals are thoroughly finished, and excellent results have been obtained with these cattle at the Smithfield Show in London.

Longhorn. These are the remains of an old breed, at one time widely distributed over the British Isles. In many ways they resemble the shorthorn, the colours being the same, but they are distinguished from them by their long, down-curving horns. A few herds are still in existence, as in some parts of the Midlands. This is the breed that Robert Bakewell selected for improvement by his method of in-breeding, but since his time they have been supplanted by the shorthorn.

Scottish Breeds: Ayrshire. This is the noted dairy breed of Scotland, the milk being specially adapted for purposes of cheese-making. Their home is Ayrshire and the neighbouring counties. The breed is characterised by a peculiar curve upward of the horns, and the colour is usually white and red, or white and brown, the patches being distinct. They have beautifully shaped udders of large capacity, long and shallow, with small teats, and carried well forward and up behind. The cattle make indifferent feeders after they are past milking, but during their prime they never fail to produce a large flow of milk off inferior pastures.

Highland. On account of its picturesque appearance this West Highland or Kyloe breed is often made use of as park cattle in England. Their home, however, is Argyllshire and the western islands of Scotland, where they live under natural conditions. The colour varies from creamy yellow to brown and black; the coat is long and shaggy, and the horns are set wide apart. It is the hardiest of all British breeds, but the animals are slow in coming to maturity, although the beef, when grown, is of first-rate quality.

Aberdeen-Angus. These cattle are natives of Aberdeenshire and the north-east of Scotland, and used at one time to be spoken of as "doddies." The colour is a whole black, with hornless head and poll coming to a "peak." They are hardy, low-set, deep-framed cattle, which kill well, and, on account of the attention paid to them in recent years, come earlier to maturity than the other Scottish breeds. They are noted for the quality of their flesh and symmetry of form, and win many prizes at the leading fat-stock shows.

Galloway. The habitat of this breed is the south-west of Scotland. They have particularly strong constitutions, as they have not been in-bred, and are consequently slow in coming to maturity. It is a polled breed, with the crown more rounded than in the case of the Aberdeen-Angus. They are also rather smaller and rougher in the coat than the latter breed. The colour is generally black, but reds and browns may appear. The breed crosses well with the shorthorn, and a white shorthorn bull mated with Galloway cows produces the "blue-greys" famed for feeding qualities.

Zetland or Shetland Cattle. These are a small, hardy breed, black and white in colour, found in the Shetland Islands. They may be looked on as a mountain breed living under natural conditions, and have been little improved.

Welsh Breeds. At one time Wales could boast of several breeds of cattle, and some of these are still extant. Up to a short time ago two principal black breeds were recognised, and had herd-books of their own—the North Wales, or Anglesey black, and the South Wales—but these two breeds have now been merged under one society known as the "Welsh Black Cattle Society," with one herd-book and one special type selected as a standard.

The North Wales breed, which comes from Anglesey and North Wales, is more particularly noted for its beef-producing qualities. Its horns are whiter and not quite so long as in the South Wales type. These cattle supply the store cattle in so much demand in the English Midland counties for grazing purposes, and pass under the name of "runts." They are somewhat slow-growing, but, when well finished, kill out to great weights, forming excellent carcases of beef.

The South Wales breed has a reputation for the production of milk, notwithstanding that they have coarse frames, and are slow in coming to maturity. They thrive and milk well on poor hill pastures.

The Welsh breeds generally have a good reputation in the south of England both for milk and beef production in spite of being somewhat slow growers. They are also a very popular breed in America.

Channel Islands Cattle. These cattle were for many years imported into England under the name of "Alderney," although the animals from this island have always been the least important of the three sections.

The cattle from Jersey have been bred pure for a number of years, owing to the strict regulations against the importation of foreign blood. They are graceful, deer-like cattle, with slender frames, large, lustrous eyes, delicate ears lined with orange-tinted skin, and horns curved forward with black tips [page 1754]. The colours most in vogue are fawn or silver-grey, with black points. The breed is noted for its rich milk, with high butter-ratio, but the animals are of little use for feeding purposes. There are two distinct types of pure-bred Jersey—the small, delicate Channel Islands type, and the coarser English-bred and acclimatised animal.

In general appearance the Guernsey [page 1754] differs from the Jersey, being a larger and somewhat coarser-boned animal. The colours also are broken and in patches, white appearing in the light yellow or brown. The noses are flesh-coloured. This breed is also noted for the high quality of its milk, which is even richer than that of the Jersey.

Irish Breeds. The bulk of the cattle in Ireland are shorthorns, and the Irish Department of Agriculture and Technical Instruction has taken much pains to improve the type throughout the country by the distribution of "premium" pedigree bulls in various districts. Under this treatment the character of Irish store cattle, imported in such large numbers into Great Britain, has improved.

The home of the small and hardy native Kerry breed is in the south-west of Ireland, and owing to their many good qualities they have spread in many directions. They thrive well on poor pastures, and give a large flow of milk in proportion to their size. The colour is black, with a splash of white on the udder, and the skin should be of an orange tint. The horns are white, wide apart, black-tipped, and curving upward. The breed is somewhat slow in coming to maturity, and is principally recognised for its dairy qualities.

The Dexter Kerry is a fancy breed which has been developed by selection from the Kerry. The shape is like a shorthorn in miniature, and the animals are smaller, shorter-legged, and more substantial than the ordinary Kerry. The colour is black, although red sometimes appears, and one characteristic of the cows is the enormous udders, carried close to the ground. The cattle have a reputation for producing excellent carcases of small beef.

DRYSDALE TURNER

The Work of John Dalton and Democritus, the First Atomist. Preparation of Compounds. Water. Hydrochloric Acid. Ammonia. Salt.

THE LAWS OF COMPOUNDS

Having completed, so far as is possible, our discussion of the elements, but deferring our consideration of the most remarkable of them all—radium—which raises so many new questions, we now pass on to the study of compounds in general, and must discuss some of those simpler inorganic compounds which are of great importance, but have not hitherto been adequately dealt with. We have already discussed the difference between a compound and a mixture.

We saw that a mixture, such as the air, consists of a number of molecules of different kinds, each of which is composed of similar atoms, whereas the essential character of a compound is that it consists of molecules composed of dissimilar atoms, molecules in which the atoms of one element go about in the company of the atoms of one or more other elements. Our conception of the real meaning of the word "compound" depends upon our conception of the meaning of the word "molecule."

Furthermore, we are already familiar with those formulas which express the number and kind of atoms that go to compose the molecules of certain compounds; while we have already noted the facts that, when elements unite to form compounds, they do so in fixed proportions; that any given compound always contains the same elements in the same proportions; and that thus the most obvious fact which distinguishes a compound from a mixture—the fact from which the others have been inferred—is the fact of definite composition.

The Atomic Theory. The real meaning of all these facts was most clearly understood and formulated by John Dalton, who must be regarded as the modern founder of the atomic theory. We must insert the word "modern," because there was an illustrious Greek named Democritus, who flourished in the fifth century before Christ, whom we must regard as the first atomist; and his views upon the ultimate atomic structure of matter have received expression which is secure of immortality, in the magnificent poem *De Rerum Natura* ("Of the Nature of Things"), written by the Roman Lucretius, who lived in the first century before Christ.

But of course there is all the difference in the world between the splendid imaginative efforts of poets and philosophers and the scientific establishment of their theories. As has been very well said, "he discovers who proves." And from our standpoint as students of chemistry it is necessary to pay much more attention to John Dalton than to Democritus or Lucretius, though we may be prepared to admit that their genius was in many ways incomparably superior to his. He it was, at least, who removed the atomic theory from the realm of speculation, however brilliant or sublime, and established it as the logical basis of modern chemistry, which we may thus assert to be only a century old.

This remarkable and gifted man was born at Manchester, of a Quaker family, in the year 1766. The great work of his life was the product of his maturer years, and his "New System of Chemical Philosophy," which is a classic, began to appear in 1808, its chief theory having been propounded, however, in 1804.

Splitting the Atom. We have already seen that the atom can no longer be thought atomic, and that the smallest, simplest, and lightest atom known is in reality a microcosm relatively as complex as the solar system. Hence, some critics have too hastily said that the whole structure of modern chemistry, founded by Dalton, has been swept away.

That, however, is simply nonsense. Even though we have had to modify profoundly our conception of it, yet we are still absolutely certain that there is such an entity as the atom, which, like the solar system, has a unity of its own, and of which the facts asserted by Dalton are true, even though we can no longer regard the atom as indivisible. It is an admirable instance of unity in multiplicity.

The Most Important Compounds. Having done some brief justice to this great genius, let us pass on to the consideration of compounds in general, the kinds of elements which notably form them, and the principles of their artificial preparation.

The most important compounds are composed of certain elements which may be named. In the first place there are the halogens—we will not pay the reader the poor compliment of naming them again—which, as the word implies, tend to form salts. Their compounds are called halides. Then there are the two elements which we treated together, oxygen and sulphur, simple compounds of which with other elements are called oxides and sulphides. Carbon also forms simple compounds with other elements, called carbides, while those of nitrogen and phosphorus are called nitrides and phosphides.

The reader will observe the uniformity of the terms, which all end in "ide," and which indicate compounds consisting of the element in question with one other element. When we have double compounds, such as calcium carbonate, $CaCO_3$, different terminations are employed; the compound is not a carbide, but a carbonate.

Preparation of Compounds. Countless compounds occur in Nature, but these can be artifically prepared in the laboratory, and recent chemistry has also been able to prepare thousands of compounds which do not occur in Nature at all.

The first and simplest method is obviously that of direct union—as, for instance, when, as we saw on page 960, oxygen and hydrogen combine under the influence of the electric spark to form water. The commonest instances of direct union are cases of oxidation, which has already been defined as combination with oxygen. As a rule, light and heat are produced when this occurs, and in such cases we apply the term "combustion" to the process. Very nearly all cases of combustion are oxidations.

Combustion without Oxygen. But there are instances of combustion in which oxygen is not involved. Hydrogen, for instance, will burn in chlorine, and so will many other elements; and, as we should expect, certain elements furnish instances of combustion with sulphur, which, in this respect again, thus resembles oxygen. The second instance we have already seen illustrated when we dealt with the preparation of elements. For when we turn an element out of one of its compounds, a process which we saw to be one of the recognised methods, we form a new compound. For instance, when sodium turns hydrogen out of water, sodium hydroxide ($NaOH$) is formed.

Compounds are also formed when other compounds are heated; when, for instance, we heat calcium carbonate, which is a double compound, we get two simpler compounds, carbonic acid (CO_2) and quicklime (CaO). *Double decomposition* is the last method we need note, and a very important one. The name practically explains itself, and implies the change which occurs when two compounds exchange partners, so to speak. It is of use when one of the new substances produced is spontaneously separable from the other, either because it is volatile, and so passes off, or because it is insoluble, and thus separates in solid form, or is precipitated, to use the technical term.

An excellent instance is furnished by the change which occurs when solutions of common salt and silver nitrate are mixed with one another. This is also of interest in explaining the fact that common salt, in virtue of this change, is the best antidote when silver nitrate has been swallowed. The formula of silver nitrate is $AgNO_3$, and we may regard the compound as consisting of two parts, one the metal and the other the group of atoms, NO_3. When this interacts with common salt, the formula of which is $NaCl$, partners are exchanged, the NO_3 group going with the sodium, and the chlorine with the silver. The chloride of silver formed is insoluble, and can be separated. Being insoluble when formed in the stomach by the administration of sodium chloride in a case of silver nitrate poisoning, it is harmless.

The following equation represents the double decomposition:

$$AgNO_3 + NaCl = NaNO_3 + AgCl.$$

We may now consider some important compounds which demand separate treatment, and of these the first is the most important compound of all, *water*.

Water. This covers much more than half of the earth's surface, is contained in greater or less degree on what we call the dry land, occurs as ice and snow in many parts, is always present in greater or less quantity in the atmosphere [see PHYSICS], and in its liquid form is an essential constituent of all living things. Chemically considered, even an Aristotle or a Shakespeare is about four-fifths water, a fact which is of interest to the chemist, but also of interest as showing how ridiculously inadequate, from the point of view of the psychologist and the philosopher, is the merely materialistic estimate of man.

We have also seen that water occurs in abundance in a less obvious form as water of crystallisation in many crystals.

This compound may be prepared, as we have already seen, by the direct union of oxygen and hydrogen, and by others of the methods of preparing compounds mentioned above. Most of the remarkable physical characters of water have had to be discussed in PHYSICS.

For the chemist, water is the almost universal solvent. There are very few substances indeed —solids, liquids, and gases alike—of which a tiny proportion at least is not soluble in water, the rule being that solids are more soluble in hot than in cold water. The nature of hard and soft water was discussed under "Calcium" [page 1099]. We saw in our first section that the discovery of the compound nature of water, regarded as an element since the days of the Greeks—since the dawn of thought—stands to the credit of Henry Cavendish, who made this most important discovery in 1781.

Hydrochloric Acid. This very important acid, to which we have made incidental references, may be compared with water, in that it is a compound of hydrogen with another element. Its formula is HCl, only one atom of hydrogen being necessary for one atom of chlorine, each of these elements being one-handed, or monovalent. We are very apt to think of hydrochloric acid as a liquid, but it is really a gas, somewhat heavier than air, and is often looked on as a liquid because it is extremely soluble in water, which is able to dissolve seven hundred times its own volume of this gas. An older name for hydrochloric acid, still quite frequently seen, is muriatic acid.

The gas is occasionally found in Nature near volcanoes, but this source is of no practical importance. It may be prepared in many ways—such, for instance, as the direct union of gaseous hydrogen and chlorine, or by the action of sulphuric acid on common salt. This is an instance of double decomposition. The following is the equation that represents it:

$$NaCl + H_2SO_4 = NaHSO_4 + HCl,$$

the hydrochloric acid being given off as a gas, and the acid salt called *acid sodium sulphate*

or *hydrogen sodium sulphate* ($NaHSO_4$) being formed. We may make a mental comparison between the formula of this salt and that of what we may call normal sodium sulphate (Na_2SO_4). The acid salt is so called because, as the reader will see, only one of the hydrogen atoms of the sulphuric acid has been replaced by sodium in the molecule of the acid salt.

Hydrochloric acid, in the form of its solution in water, is a very powerfully acid and corrosive liquid, having the typical properties of an acid. It is largely made as a preliminary to the making of sodium carbonate or washing soda. It is an extremely remarkable fact that this potent acid may be regarded as one of the natural antiseptics of the body, which produces it for itself, as we shall now see.

Hydrochloric Acid in the Stomach. Hydrochloric acid is a constant and necessary constituent of the juice of the stomach, in which it plays two very important parts. The first, which is generally recognised, is to aid in the digestion of the most important kinds of foodstuffs, which are called proteins. The second, the importance of which is only now beginning to be appreciated, is to act as an antiseptic. It has been shown that there are many kinds of diseases the microbes of which cannot survive in gastric juice, and which can attack us only by entering the body elsewhere, as through the lungs, or passing through a stomach which is out of order. The Royal Commission on Tuberculosis has now reported that the presence of hydrochloric acid in the stomach is probably the means by which we are almost always saved from the living microbes of tuberculosis which are present in, for instance, one sample in every ten of London milk.

But these are matters hardly of chemistry. The really amazing fact for the chemist is the mode of production of this acid by the wall of the stomach. Its source, as in the ordinary commercial process, is sodium chloride ($NaCl$). This is one of the firmest and most stable compounds that we know. In order to decompose it and form hydrochloric acid the manufacturer finds it necessary, in the first place, to employ one of the most powerful of all acids—sulphuric acid—and in the second place to use great heat, so as to permit of the decomposition.

Chemical Power of Living Cells. But in the human body there is no sulphuric acid, nor is there anything like the heat which the manufacturer employs, yet such is the potency of the living cells in certain of the glands in the wall of the stomach that, in some way which we have not yet begun to understand, they are able to decompose this firm compound, sodium chloride, at the mere temperature of the blood.

This decomposition seems to the writer to be, perhaps, the most amazing of all proofs of the chemical power of the living cell. The proof of this power that is most often quoted is the remarkable decomposition of carbonic acid (CO_2) in the atmosphere by means of the living cells of the green leaf. The necessary agent in this decomposition is the green matter found in the cells of the leaf, which is called *chlorophyll*. Now, carbonic acid is a compound even firmer than sodium chloride, and the temperature at which the leaf decomposes it is far lower than that of the blood.

Hence it would appear as if this decomposition were more remarkable than the formation of hydrochloric acid in the stomach. It looks as if the chlorophyll of the leaf were to be regarded as a sort of ferment—one of those extraordinary substances which have the power of producing chemical change, though themselves remaining unchanged. But Sir James Dewar, in conversation with the writer, observed that this is not the way in which we should look upon chlorophyll; rather, in his opinion, should we regard it as a means of condensing or, to use an excellent metaphor, focussing the sunlight which—and not the chlorophyll—is the essential factor.

The Energy of Sunlight. The energy by which this firm compound, carbonic acid, is decomposed is thus the tremendous energy of sunlight, suitably utilised, adapted, condensed (whatever word we may use to veil our ignorance) by means of the chlorophyll of the living cell. In the case of the decomposition of the sodium chloride in the cells of the stomach, however, sunlight is neither available nor necessary. The work is effected, not by the transformation or utilisation of the solar energy, but by means of the mysterious energies which are available in the living cell itself. Therefore we think that this decomposition, with its ease, its lower temperature, and the absence of any visible decomposing agent such as sulphuric acid, as compared with the means which the manufacturer has to employ, may be regarded as perhaps the most signal instance of the possession of chemical powers by the living cell.

Ammonia. Here, again, as in the case of water and hydrochloric acid, is a simple compound of hydrogen with another element, in this case nitrogen, the formula of ammonia being NH_3, as was mentioned when we discussed nitrogen. In the case of water the hydrogen was combined with a two-handed element, so that, itself being one-handed, two of its atoms were required in order to unite with one of oxygen. In the case of hydrochloric acid the united element was also one-handed, and in the case of ammonia we find that the united element is to be regarded as three-handed, or trivalent.

This substance, like the last, is a gas at ordinary temperatures, colourless, but by no means odourless. Its effects upon the nose, however, are not confined to the stimulation of the sense of smell. Its pungency should be distinguished as composed of two parts, one consisting of its irritation of the ordinary sensory nerves of the nose, and the other consisting of a true stimulation of the nerves of smell. The gas is lighter than air, and is even more soluble in water than is hydrochloric acid. The solution, which is often loosely called ammonia, indeed contains as much ammonia as is equivalent in volume to about eight hundred times the volume of the water in which it is dissolved, the exact

proportion varying with the temperature [see PHYSICS]. The solution has all the characteristics of an alkali, and, indeed, ammonia is commonly called the *volatile alkali*, since, being essentially a gas, and therefore volatile, it is contrasted in this respect with soda, potash, and lime, which are called *fixed alkalies*. We have, indeed, good reason to assume that, when ammonia gas is dissolved in water, something rather more than mere solution occurs. There is doubtless some sort of combination between the ammonia and the water—certainly a very unstable combination, but still more than a mere solution; and we may conveniently represent what happens by adding together the formula of ammonia and the formula of water, thus:

$$NH_3 + H_2O = NH_4OH$$

Ammonium. When we look at the formula of this supposed substance, writing it in the fashion seen, and not in the most obvious way, which would be NH_5O, there is suggested to us a parallelism between this and the formula of soda, or lime, or potash. The latter, for instance, is KOH, and the K corresponds to the NH_4. Now, this NH_4 seems to be such an independent reality that it has been given the special name of ammonium, and must probably be regarded as a metal. The reader will answer that it is absurd to talk about a compound of two gases as a metal. "Why, it is not even an element!" he may say, but, then, all our ideas of elements have undergone a change; and if the existence of the compound metal ammonium was probable ten years ago, it is still more probable today. In theory its existence is extremely probable, and the parallelism between its compounds and those of the other metals is most marked. There is, indeed, a small amount of evidence in favour of the view that the transient existence of ammonium in its metallic form has been experimentally demonstrated.

What we must probably regard as an ammonium amalgam—that is to say, a probable combination of the metal ammonium and the metal mercury—is a butter-like metallic mass which is produced when sodium amalgam (a white substance made by mixing sodium and mercury) acts on a strong solution of ammonium chloride (NH_4Cl) [compare KCl]. This amalgam, however, is, as might be expected, very unstable, doubtless owing to the instability of the supposed ammonium, and quickly decomposes into mercury, ammonia, and hydrogen.

Gaseous ammonia forms a colourless liquid at a temperature of about $-33°$ C., and freezes at $-75°$ C.

Sources and Preparation of Ammonia. Small quantities of ammonia occur in the air, whence some of the compound is carried by rain into the soil and rivers. The occurrence of ammonia in the soil is of the utmost importance in relation to plants. As we saw when discussing nitrogen, this element is a constituent of protoplasm, the physical basis of life; and the plant has to obtain it from the soil. The form in which the plant obtains its nitrogen is mainly in the compounds—salts of nitric acid—which are called nitrates.

Now, it has been discovered that the ground contains particular kinds of microbes or bacteria which play an all-important part in this connection, and which are thus to be regarded, humble though they be, as a necessary link in the chain of events upon which human life itself depends. For it is from plants that all animals derive their necessary nitrogen. These organisms take the ammonia of the soil, and with the aid of oxygen, which is abundantly present in its elemental form in the soil air, and also in combination, they convert it into nitric acid (HNO_3). This typical acid reacts with the typical alkali, lime, which occurs in the soil, and forms calcium nitrate, in which form the plant thus obtains its nitrogen.

Ammonia from Decomposition. Ammonia is also formed by the decomposition of animal and vegetable matter. Certain salts of ammonium may be obtained in a similar fashion. Amongst these is sal-ammoniac—the old name for ammonium chloride—and also the carbonate of ammonium $(NH_4)_2CO_3$, which is usually known as smelling-salts or spirits of hartshorn, a name which hints that it may be obtained by distilling the horn of stags.

In addition to these more or less natural sources, ammonia may be obtained by the direct union of hydrogen and nitrogen, provided that one or other or both be in the nascent state, which we fully explained in an earlier section. But the most common method of preparing ammonia is by double decomposition—sal-ammoniac being heated with quicklime, with the formation of calcium chloride, which is highly soluble in water, while ammonia gas is liberated, and, being lighter than air, may be collected by an inverted vessel placed above it. The following equation represents the reaction:

$$2NH_4Cl + CaO = CaCl_2 + H_2O + 2NH_3.$$

Ammonia and the Alkaloids. Ammonia has extremely marked and important reactions in relation to living matter, upon all forms of which it acts as an irritant and a poison. Properly administered, it is a stimulant, as everyone who has used smelling-salts knows. It is one of the most powerful and rapid of all konwn stimulants of the heart and lungs, and it is therefore of superlative value in emergencies, especially as its physical form enables the patient to breathe it, and thus to obtain its action even more quickly than in the case of a liquid stimulant injected under the skin.

The behaviour and structure of ammonia are also of great interest in the more obscure regions of chemistry, because of the existence of a very large and important class of substances called *alkaloids*. These are mainly produced by plants, and include such extremely potent drugs as morphine and strychnine. They are called alkaloids in order to indicate their resemblance to alkalies. (The termination "oid," so often seen in scientific and philosophical language, is Greek, and implies likeness.) Now, there is good

reason to believe that it is the presence of ammonia in the molecule of these alkalies upon which their alkaline properties depend. Thus we are not at all surprised to learn that all alkaloids contain nitrogen and hydrogen.

Marsh-Gas. At this point we might proceed to discuss another simple compound of hydrogen with the four-handed element carbon. This compound is known as *methane*, or *marsh-gas*, and has the formula CH_4, but it is better discussed later as an introduction to organic chemistry, or the "chemistry of the carbon compounds."

In dealing with the most important elements, with their properties in sequence, and in thereafter returning to the consideration of their important compounds, we have adopted a plan of which one of the advantages is this: that the student can scarcely be successful in his study of compounds unless he has already learnt the main facts of the elements constituting them. This necessity would not obtain if we took up each element and its compounds together.

Compounds of the Halogens. In proceeding, then, we assume that the reader is already familiar with, at any rate, the outstanding facts of the elements; and the first group of compounds to which we shall refer are those of the halogens, which were discussed in their turn in a recent section. The acids which correspond to hydrochloric acid are much less important, and need not further be discussed, or even named. But there is one pre-eminent compound which demands careful treatment.

Common Salt. We are already familiar with the technical name of common salt, which is sodium chloride (NaCl). It is an extremely abundant compound, constituting from 3 to 5 or 6 per cent. of sea-water, a much higher percentage of the waters of certain salt lakes, such as Salt Lake, in America, the Caspian, and the Dead Sea, and also occurring in immense deposits in various parts of the world, where it indicates the past existence of salt lakes which have dried up. When it is obtained by the present evaporation of sea-water it is often called *bay-salt*, whilst the deposits depending upon past evaporation are called *rock-salt*. It may be mined, or the deposits may be flooded and pumped up as brine, which is then evaporated, or (as still, in many parts of the world) it may be obtained by the evaporation of sea-water. It forms cubical crystals, which melt at a high temperature, and is readily soluble in water, being more soluble in hot water than in cold. Its artificial composition is thus superfluous, but it might be obtained by burning sodium in chlorine gas, or by the action of hydrochloric acid on sodium or on caustic soda or on sodium carbonate.

Salt and Life. Salt, being a necessary article of food, has played a part in many ceremonies of many ancient peoples; and has very frequently been taxed. We tax it in India today to some extent; but it should be recognised that a tax on salt is a tax on food, and in hot countries, such as India, where salt, which has mild antiseptic properties, is extremely necessary not only for itself, but as a means of preserving fish and other food, the propriety of a salt tax is, to say the least of it, dubious.

Salt and Food. The proportion of salt that occurs in different foods varies widely. In general, salt has to be added to the diet of the vegetarian, man or animal, while the meat-eater obtains enough in the muscular tissue which he consumes. The imperative necessity of salt for life is illustrated by the extraordinary accounts of the wild flights of herbivorous animals in America, long deprived of salt, towards "salt-licks," or places where they can satisfy themselves by licking deposits of sodium chloride.

The saltness of the sea is a fact of the utmost interest in relation to the history of the earth. If we discuss all the salts of the sea in general, we find that they are carried down to it by rivers and streams, which dissolve them from the soil and land through which they pass. As the sea-water evaporates, the salts are left behind, and thus they accumulate—the sea is becoming salter every day. This fact has lately been utilised, not without success—that is to say, agreement with results obtained by other methods—in an attempt to estimate the age of the earth's crust from the present saltness of the sea and the probable rate at which addition is being made to its saltness.

Carbon and Chlorine. Another halide which is of great interest on theoretical grounds is called carbon tetrachloride, and has the formula CCl_4. Its interest depends upon its relation to methane or marsh-gas (CH_4), already mentioned. For if this be exposed to the action of chlorine, atoms of this gas successively replace atoms of hydrogen, hydrochloric acid being meanwhile formed. The substances which are produced have the formulas (starting from marsh-gas, CH_4), CH_3Cl, CH_2Cl_2, CH_3Cl, ending with carbon tetrachloride, CCl_4. The body produced when three atoms of hydrogen have been replaced by chlorine is chloroform, $CHCl_3$. As we might expect from their chemical resemblance, its two predecessors have similar properties, and are occasionally used in surgery.

The Halides of the Nitrogen Group. The nitrogen group, consisting of nitrogen, phosphorus, etc., forms a series of compounds with the halides, but these are not of great importance. The best-known are the trichlorides, such as nitrogen chloride (NCl_3), phosphorus chloride (PCl_3), etc., whilst phosphorus and antimony also form what are called pentachlorides, such as PCl_5, phosphorus pentachloride, in which the phosphorus is five-handed.

Final Note on Halides. The other halides that are of sufficient importance have been dealt with already. It is well to remember a general rule which the halogens follow in replacing one another in their compounds. In the case of the salts of sodium and potassium, at any rate, chlorine will turn out bromine and iodine, and bromine will turn out iodine.

C. W. SALEEBY

The Story of the Crusades. The Conflict between Pope and Emperor. The Journey to Canossa.

THE HEROIC AGE OF CHIVALRY

THE result of two centuries of anarchy and barbarian invasions, together with the feudalism which they had called into being, was to intensify the military spirit and to bring back into life the old theory of the forest-traversing Germans, that war was the only fitting occupation for a freeman, or, in modern language, for a gentleman. Immured within his massive castle, seeing all the lands up to the horizon cultivated by serfs "tied to the soil" or by men-at-arms, his vassals bound to follow him in war, the knight, or baron, or earl, who was the only really important unit in mediæval society, accepted the excitement of the chase as making life tolerable, but longed for the more glorious excitement of the stern realities of war. Even his religion was of the militant type. As one of the early Teutonic converts said when he heard the sad story of Calvary: "Had I been there with my henchmen, I would never have allowed the Romans to nail Him to the Cross."

Thus the spirit of that age, especially in those countries where the young Norman nation made itself most manifest, might be expressed in two words: *Militant Christianity*. It was almost as if the religion of Christ and the religion of Mahomet had changed places. Faith longed to display itself by deeds, but they must be deeds such as the mail-clad warrior only could perform There was a certain nobility of spirit about that brave ignorance. The heroic age of chivalry must certainly be placed in the two centuries which we are about to review rapidly—the centuries of the Crusades.

The fuel was all laid ready for the fire when Peter the Hermit, a mean-looking figure riding on an ass, but bearing aloft the crucifix and breathing the fiery eloquence so often given to men with one idea, went through the cities and villages of France proclaiming the hardships, the humiliations, even the cruelties which Christian pilgrims to the holy places in the East had to endure at the hands of the Mussulmans. Once comparatively mild, the yoke pressed upon them had become ten times harder since—in the year 1076—the fierce Seljuk Turks from Tartary made themselves masters of the sacred lands. The Church of the Holy Sepulchre had been demolished, the Patriarch of Jerusalem had been dragged along the pavement by his hair and thrown into a prison, from which he was released only on the payment of an enormous ransom; everywhere the Christian pilgrims were being plundered, insulted, maltreated.

With all these exasperating stories in men's minds, when Pope Urban II. convened a council at Clermont, in France, in 1096, and pleaded for an armed expedition to rescue the holy places of Jerusalem from the infidels, promising the forgiveness of all sins to those who should start on such an expedition, and an immediate entry into Paradise for those who should die in its service, the well-known cry "Dieu le veult!" burst from thousands of excited hearers; the badge of the Cross was assumed by all sorts and conditions of men; the Crusades began their chequered and feverish life.

The period of the Crusades lasted for 176 years (1096–1272), and during that time eight great expeditions, besides numberless smaller ones, were launched from Europe against Asia. It will thus be seen that the average interval between each crusade was a little less than the average length of a generation. That was the time necessary to rekindle in the bosom of the French or Norman knight the enthusiasm which had sent his father to the Holy War.

France, which had been the scene of the first proclamation of the Crusade, still remained the chief supporter of the movement—France and her sister-land of Flanders, and her kinsfolk the Normans of England and Italy. Spain was too much occupied with her own domestic crusades against the Moors, Germany too keenly interested in her long battle with the Popes and the internal dissensions resulting thence, to give her

whole mind to the recovery or the defence of the holy places, though three of her emperors at least took some share in a crusade. French or Flemish or Norman remained the chief material forces of the long campaign, and French were its two chief spiritual champions—Peter the Hermit (1093–1099) and Bernard of Clairvaux (1146–1153).

Jerusalem Regained. The First Crusade, the most successful and the most memorable of the number, that one which inspired the Italian poet to write his epic "Gerusalemme Liberata," lasted three years (1096–1099). It saw the Turks defeated in the great battle of Dorylæum, in Bithynia, Antioch taken, and at last, most joyful of triumphs, Jerusalem itself recovered from the infidel in July of 1099. In that holy city, when Godfrey of Boulogne was proclaimed, but not crowned king, a dynasty—a "Latin Christian" dynasty—was established, with laws and polity all its own, the very embodiment of feudalism; and this dynasty lasted with varying fortunes for nearly a hundred years (1099–1187), till it was overthrown by the Mussulman soldier of fortune, Saladin. In this crusade, Robert the Norman, eldest son of William the Conqueror, took an important part, having pawned his Duchy of Normandy to his brother Rufus in order to raise money for the enterprise.

A Province and an Unhappy Home. The Second Crusade (1147–1148), though pleaded for with enthusiastic eloquence by the great Saint Bernard, was a poor and ineffectual affair, memorable in French history chiefly from the fact that it led to the loss of the province of Aquitaine. Eleanor, the heiress of that goodly land, had brought it as a dowry to her husband, the French king, Louis VII. The young pair went together on crusade, quarrelled, as many other travelling companions have done, and were divorced. Eleanor, marrying a second time, brought to her new husband, Henry Plantagenet, King of England, the right to that splendid inheritance along with her own unrivalled capacity for making her husband's home miserable.

The son of Eleanor of Aquitaine, Richard Lion-Heart of England, was the chief hero of the Third Crusade (1189–1192). He failed to recover the Holy City from the grasp of Saladin, but he captured Acre, and his personal bravery did something to restore in the East the fading lustre of the Christian arms. It is needless to do more than refer to the well-known story of his quarrels with Philip Augustus of France, his captivity in Austria, and the enormous ransom which was extorted from him by the mean-souled German emperor.

ST. BERNARD EXHORTS KING CONRAD III. OF GERMANY TO JOIN THE CRUSADES

The Founding of a Bogus Empire. The Fourth Crusade (1202–1204) was a tragicomedy, played with a disastrous disregard to the true interests of Christian civilisation. Venice, Champagne, and Flanders furnished the bulk of the Crusaders, who never approached within a thousand miles of Jerusalem, but, instead of fighting the infidel, occupied themselves in overturning the Christian Empire of the East, the barrier which had for six centuries protected

Europe from the ravages of Saracen invasion. A shadowy "Latin" Empire was founded when Baldwin, Count of Flanders, was crowned with the diadem in Constantinople, and the Republic of Venice became sovereign of "one-quarter and the half of a quarter of the Roman Empire," and countless principalities, marquisates, and baronies were allotted to French and Flemish knights on the coasts of the Ægean.

Opening the Door to the Turk. But none of these stage sovereignties, though picturesque and romantic, had enough inherent vitality to enable them permanently to resist the rising tide of Mussulman conquest. That a Turkish sultan now sits as lord in the palace of Constantine is a direct—we might almost say an inevitable—consequence of the felony of the Fourth Crusade.

THE CAPTURE OF CONSTANTINOPLE BY THE CRUSADERS

The Latin empire of Constantinople had an even shorter life than the Latin kingdom of Jerusalem. In 1261 the Greek emperors were back in their own city, but so weakened and impoverished that we learn with surprise that the final ruin of the empire was postponed for nearly 200 years.

Crusading in Egypt. From this point onwards the story of the Crusades becomes rather monotonous. There was scarcely any fighting in the Holy Land itself, the Crusaders having apparently decided that the conquest of Palestine must be achieved in Egypt. The Fifth and Seventh Crusades (1216–1221; 1245–1250) were occupied chiefly with operations round Damietta, which was twice taken by the which might, with a little prudent management, have been exchanged for Jerusalem. The hero, or, rather, the saint and martyr, of this Seventh Crusade was Louis IX. of France, who, after some successes, was taken prisoner by the Egyptian sultan and released only on the payment of an enormous ransom.

Twenty years later—in 1270—St. Louis headed the Eighth Crusade, but died of fever at Tunis at the very beginning of the expedition. Edward, son of Henry III. of England, remained in command, went forward to Palestine, landed at Acre, and took the holy village of Nazareth. His success, however, ended there. He fell sick, narrowly escaped death at the hand of an assassin, and returned to England in 1272 to mount the throne and begin a memorable reign as Edward I. This was virtually the last of the Crusades, and, like the first, it was connected with the personality of a chivalrous Anglo-Norman prince.

The Unlooked-for Effects of the Crusades. We have seen that the Crusaders were essentially a product of feudalism, but it is also true that their influence was in the end antagonistic to feudalism. Contact with nations of an utterly different type of civilisation, with the Greek, the Egyptian and the Arab, brought new ideas and shook the mail-clad warrior out of his stolid, knightly pride. The multitude of lowly born peasants who flocked to the banner of the Cross loosened the hold of the landowner on his serfs; the impoverishment of the chivalrous classes

and the diminution of their numbers increased the relative strength of the crown; above all, the spread of commerce, which was undoubtedly a result of the Crusades, augmented the wealth and power of the *Communes*, whom we find throughout these centuries rapidly rising into importance, and who were, moreover, often able to buy valuable charters and remissions of obnoxious burdens from a knightly or baronial neighbour, who must have money at any price to enable him to start for the Holy Land.

A New Weapon for the Papacy. Yet it would not be safe to assert that the influence of the Crusades was all on the side of enlightenment and freedom. On the contrary, it put a dangerous weapon into the hands of the papacy, which was now sometimes able to get rid of teaching in which it detected a menace to its claims by declaring its advocates heretics, and proclaiming a Crusade against them. A notable instance of these tactics was furnished by the Crusade against the Albigenses, engineered by Innocent III. (1209-1217), a Crusade which crushed the gay, poetic, free-thinking civilisation of Southern France, and possibly postponed for some three hundred years the reformation of the Church.

RICHARD, LION-HEART, ENGLAND S CRUSADING KING

The Rise of Hildebrand. The German emperors had done a good deed for Christendom by helping to raise the papacy from the slough into which it had fallen, but they had not altogether promoted their own ease or security. Throughout the closing years of our second period the dominant influence in the counsels of the papacy had been wielded by the cardinal sub-deacon Hildebrand. It had ever been his voice which stimulated the Popes, his nominal superiors, to assert the claims of their office against the authority of the emperor. By his advice Pope Alexander II. had commissioned William the Norman to undertake the conquest of England. By his contrivance the momentous change had been made which transferred the election of the Pope from the people of Rome to the bishops and clergy of that city, who bore the name of cardinals. In 1073 the great pope-maker consented to become Pope himself.

The Natural Rivalry of Pope and Emperor. The cardinal Hildebrand began his short but ever memorable papacy under the title of Gregory VII. (1073-1085). There is an old and true proverb that if two men ride on one horse one of them must go behind. Such had been for centuries the condition of Europe under the empire founded by Charlemagne, and till now the question had never been fully faced which of the two riders, emperor or pope, was to take the hindmost place. One of the two riders claimed to represent the immemorial domination of Rome, to be the successor of Julius, of Augustus, and of Constantine, and to possess all their pre-eminent rights. The other claimed to be the vicar of Jesus Christ, God's vicegerent upon earth, and the claim was generally admitted for all that concerned the religious interests of mankind; but the thought was now finding harbourage in the minds of churchmen that temporal matters ought also to be subjected to the same divinely appointed rule.

"Come, then," said Hildebrand to a council of ecclesiastics, "let all the world understand, and know that since ye have power to bind and loose in heaven, ye have power to take away and to grant empires, kingdoms, principalities, duchies, marquisates, counties, and the possessions of all men according to their deserts. Ye have often deprived wicked and unworthy men of patriarchates, primacies, archbishoprics, bishoprics, and bestowed them on religious men. If ye then judge in spiritual affairs, how great must be your power in secular? And if ye are to judge angels, who rule over proud princes, what may not ye do to these their servants?"

Ill-matched Antagonists. The balance of forces at the accession of Gregory VII., in 1073, was, indeed, strangely altered from that which prevailed in the previous century. Then there had generally been a weak, despised, sometimes immoral pontiff over against a strong, chaste,

A ROYAL PRISONER IN THE HOLY LAND

KING LOUIS IX. OF FRANCE IN THE HANDS OF THE SARACENS
From the painting by Cabanel in the Panthéon

strenuous emperor. Now there was a stern, austere, monk-pope matched against the dissolute, unstable, though not by any means stupid young emperor, Henry IV. Each found his worst enemies in his own house. Many Italian bishops were indignant at Gregory's determination to enforce the absolute rule of celibacy on all churchmen; many German nobles resented every attempt which Henry made to convert a nominal into a real supremacy.

Flinging Down the Gauntlet. In the year 1076 the smouldering antipathy between the two men broke out into open war. Gregory summoned the emperor to appear before him at Rome, there to answer for various breaches of ecclesiastical law. Henry retorted by convoking a synod at Worms, at which the bishops, who were his partisans, formally renounced their allegiance to Gregory and served upon him a summons, couched in insulting terms, to leave the apostolic throne which he had usurped: "I, Henry, by the Grace of God, with all the bishops of my realm, say unto thee—Down, down!"

The Effects of a Spiritual Boycott. The emperor had over-rated his power, as he soon discovered when the Pope replied with his expected counter-stroke, excommunication and deposition from the imperial dignity. The political result of this sentence, the assembling of a hostile Diet, the revolt of three of the most powerful dukes, he could perhaps have surmounted; but the social results, the loneliness and depression caused by the terrible "boycott" of excommunication—an expressive word must be borrowed from modern politics—were too much for him. In the depths of an unusually severe winter he and a few faithful followers scrambled, at the risk of their lives, over the slippery slopes of Mont Cenis. At his descent into Italy the adversaries of Gregory rallied round him, and the Pope himself retired to the castle of Canossa, a fortress high up in the Apennines, which belonged to his faithful partisan Matilda, Countess of Tuscany.

The Humiliation of the Emperor. To the disgust of his Italian allies, Henry was all for submission, for petitioning the Pope to annul his sentence of deposition; but the Pope was determined not to make forgiveness easy. For three days the emperor, clad in the thin white robe of a penitent, shivered in the courtyard of Canossa. When at length admitted, he received absolution, but on the humiliating terms of submission to the Pope's will—a promise to appear before his judgment seat to answer the charges made against him, and meanwhile to lay aside the marks of his rank and perform none of the functions of royalty.

CRUSADERS ON THE MARCH—FROM THE PAINTING BY SIR JOHN GILBERT, R.A.

This is the far-famed pilgrimage to Canossa, which profoundly stirred the minds, not only of contemporaries, but of many succeeding generations, and the echo of which was heard in modern politics in Bismarck's well-known phrase, "We certainly shall not go to Canossa."

The Weakness of Extremes. It took place in 1077, just eleven years after the battle of Hastings. In this instance it was proved that Gregory had over-strained his power. The humiliation so joyously inflicted on the greatest of its potentates revolted the conscience of Christendom. German pride was wounded by the arrogance of the Italian. Henry's affairs assumed for the time a more cheerful aspect, a second excommunication fell harmless. Rome was

besieged, and saved from capture only by the appearance of those terrible allies, the Normans, who pillaged, burnt, and ravaged worse than any of Rome's previous barbarian conquerors. Gregory died at Salerno in 1085, uttering the memorable words: "I have loved righteousness and hated iniquity; therefore it is I die in exile."

The Crucial Question of Investitures. The point at issue between the two rival potentates was not merely a personal one, though undoubtedly the natural man's desire for pre-eminence played a great part in the drama. There was also one really difficult question which for more than half a century distracted Christendom—the question of investitures. The high lords of the Church, her bishops, archbishops, mitred abbots, and patriarchs, were also, especially in Germany, high lords in the state, rulers of enormous territories and entitled to the obedience of powerful vassals. Here then were two mighty organisations, the ecclesiastical and the feudal. How could these be fitted into one another? On feudal principles, all temporal power involved the feudal tie, lordship over the vassals beneath, vassalage to the lord above, and the lord paramount over all was the king.

But on ecclesiastical principles, as now asserted by Hildebrand, the dignitaries of the Church, deriving their authority from God Himself, were subject to no man, save the Pope, God's vicar. How then could the bishop or archbishop be asked to do homage to any temporal lord, even to the emperor himself? How could the hands which in the sacrifice of the Mass "could create the Creator" be pressed between the hands of a man who was perhaps an adulterer and a murderer? The symbols of the investiture of a prelate were the ring and the pastoral staff—the ring to betoken the new bishop's marriage to his diocese, the staff his duty of shepherding the flock. Where was the fitness of the bestowal of these on a churchman by an earthly potentate? Yet, on the other hand, if some of the most powerful nobles of the empire could hold their lands subject to no recognition of the emperor's supremacy, what became of feudal subordination? It will therefore be seen that the dispute about investitures was no mere strife about words, but that a real contest of principles was involved.

At one point of the struggle a Pope—Paschal II.—was actually willing to surrender all the landed domains of the Church if the emperor would give up his claim to grant investiture to her officers; but this sacrifice was too much for his episcopal clients, and negotiations on that footing had to be abandoned.

RICHARD LION-HEART DOING BATTLE WITH SALADIN AND THE SARACENS

A Settlement by Compromise. At last, however, at the Diet of Worms in 1122, a reasonable compromise was effected. Investiture by ring and staff, the religious part of the process, was renounced by the emperor, but the newly consecrated ecclesiastic must kneel before the emperor and receive from his outstretched sceptre the touch which conveyed to him dominion over the lands attached to his bishopric. The principle of the Concordat of Worms was apparently accepted in the other countries of Western Europe, and in some of them, at any rate, continues in force till this day. When a parish clergyman is selected for promotion to an English bishopric, after he has gone through the ecclesiastical ceremonies of election by the dean and chapter, consecration by his brother bishops, and enthronement in his cathedral, it is his duty to take the train for Windsor, and there do homage to the King for the temporalities of his see.

THOMAS HODGKIN

The Dumb Well. Gullies and Their Uses. Subways for Pipes. Steam and Motor Rolling. Watering. Channelling and Kerbing.

METHODS OF ROAD DRAINING

Draining the Road. Suburban and country roadways are often rendered impassable after heavy rains from the want of proper drainage. Deep ruts are formed, which become channels for the water, and there is no escape for the rainfall. One of the simplest modes of draining a country road in localities where gravel or stone may be had is to lay horizontal drain-pipes below the gravel, so that the rain will pass through to them. A good-sized pipe-tile is laid at the bottom, surrounded by small stones. On this coarse gravel or loose stones, such as quarry chippings, are laid, and above this a layer of fine gravel, then the surface gravel.

Such a drain in the centre of the roadway will often be sufficient, but for wider roads two lines of drains may be made. At all the depressions in the road, outlets must be made for the discharge of the water from the drain tile to the roadside, or natural channels, which cross the line of road. A properly compacted foundation, laid to a good inclination or section, and a well-metalled roadway and footpaths, throw off the water uniformly, and require only a few well-placed gullies to carry off the surplus rainfall.

Importance of Road Draining. Too much attention cannot be paid to the drainage of roads. When footpaths are constructed, a channel or watercourse is formed to receive the water which results from curving the transverse section of the road, and gullies are placed to about every 40 lineal yards of sewer, and at every intersection of streets, to convey the water through 6-in. pipes into a properly constructed sewer having a suitable outfall. In country roads, where there is no footpath or sewer, water tables (the width of a roadman's spade) should be cut obliquely at intervals to convey the water from the channel at the side of a road into a ditch or watercourse, thus carrying the water off before it can filter through the surface of the road.

The Dumb Well. When there are no natural outlets for the water, such as ditches, ponds, and watercourses, a *dumb well* is constructed under the path. This kind of well is dug and steined on the underpinning principle. The excavation is carried down as far as it can safely be taken without steining. An elm curb, made in two or more thicknesses, lap-jointed and cut circular, is then laid at the bottom, and the brickwork is built thereon. The excavation is then continued inside the curb. The earth supporting the curb is then cut out, with the exception of a few piers, a firm footing of timber is made in the centre of the bottom, and raking struts are put in to carry the curb; after which the piers are cut away, a new curb is put in, and the brickwork is carried up and pinned in under the old curb, which is left in position. In practice workmen often use more rough-and-ready methods, at considerable risk.

The well is then either domed right over in brickwork, or partly domed over, leaving an opening of about 2 ft. square for cleaning purposes, this opening being covered with a 3-in. York stone.

Road Drainage with Pumped Sewage. In a town or district where all sewage has to be pumped, it is of great advantage to keep the volume as low and as constant as possible; it would therefore be better to have a separate system for surface water. To give an idea of the enormous saving which would be effected in a district of this kind if the whole of a rainfall of 1 in. per hour were kept out of the foul sewers, and a 1 h.p. pump sufficed to lift the volume, it would require a 60 h.p. engine and pump to lift this large quantity of rainfall if the whole found its way to the foul sewers.

The table below is given, as rainfall plays a very important part in the designing and construction of storm and surface-water sewers.

The annual rainfall in England varies from 20 in. to 70 in., the average being 40 in.

The greatest rainfall in England in 24 hours = 3 in.

The greatest rainfall in England in one hour = 1 in.—in rare cases 1¼ in. and 1½ in.

⅛ in.	of rainfall	= ·585	gal. per yd. superficial
3/16 in.	,,	= ·878	,, ,, ,,
¼ in.	,,	= 1·171	,, ,, ,,
5/16 in.	,,	= 1·463	,, ,, ,,
⅜ in.	,,	= 1·756	,, ,, ,,
7/16 in.	,,	= 2·049	,, ,, ,,
½ in.	,,	= 2·343	,, ,, ,,
9/16 in.	,,	= 2·635	,, ,, ,,
⅝ in.	,,	= 2·928	,, ,, ,,
11/16 in.	,,	= 3·220	,, ,, ,,
¾ in.	,,	= 3·514	,, ,, ,,
13/16 in.	,,	= 3·806	,, ,, ,,
⅞ in.	,,	= 4·099	,, ,, ,,
15/16 in.	,,	= 4·395	,, ,, ,,
1 in.	,,	= 4·687	,, ,, ,,

The following is a digest of the clauses for the preparation of a specification for this class of work:

Each length of sewer shall be laid in a perfectly straight line both in the horizontal and vertical planes, the levels and gradients shown upon the drawings being rigidly adhered to unless otherwise ordered in writing; and every pipe shall be accurately boned in with a proper boning-rod arranged between two fixed sight-rails.

The lateral position of the pipes or concrete tubes must be kept true by means of a cord or wire stretched in the trench close to the proposed position of the pipes.

The pipes, concrete, and brickwork shall be laid upon an even and solid foundation.

On the completion of each length of pipe-laying or other work, after the same has been examined and approved by the engineer, the excavations are to be at once filled in over and around the work, and the ground is to be made up to the required level.

In closing up all trenches selected earth or sand free from stones, lumps, or other hard substances more than two inches in diameter, shall be carefully shovelled into the trench to a depth of 1 ft. above the crown of the sewer. This material shall be solidly rammed down on both sides of the pipes so as not to disturb them. In the case of stoneware pipe sewers in trenches over 6 ft. deep, the earth shall not be thrown direct on the pipe, but shall first be shovelled on to a portion already covered and then passed along on the uncovered portion by a labourer in the trench.

All timber used for shoring or other purposes shall be carefully drawn as the work of filling-in progresses, and never in such a way as to allow the side of trenches to cave in or slide.

The trenches shall thereafter be filled up in layers of 9 in. deep, each layer being well rammed down over the whole surface before the next layer is filled in.

Walking over sewers shall not be allowed until they have been covered with at least 1 ft. of earth. All boulders, rocks, stones, logs, and other objects of over half cwt., and such other materials as the engineer may deem unsuited for filling, shall be considered as waste material.

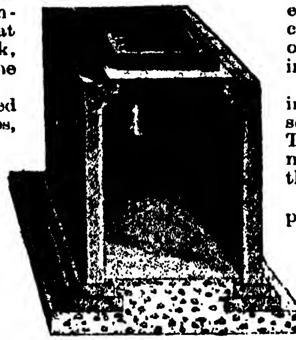
The contractor is to consolidate the ground filled in with a copious supply of water.

The joints of all pipes shall be well and truly made with Portland cement. The cement mortar used for this purpose to be in the proportion of one of washed sand to two of Portland cement, with a fillet of the same worked round the outside, the joints having been previously filled in with gaskin dipped in tar, rammed in so as to fill the extreme end of the space between the socket and the pipe for a depth of at least ¾ in. all round

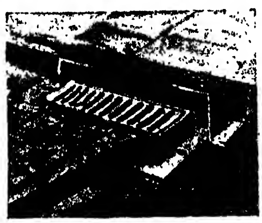
A proper tool with circular blade and long handle shall be used to take off and clean out the superfluous cement from the inside of the pipes.

All brickwork of manholes shall be executed in the most workmanlike manner; each course flushed in, grouted, and finished solid; the courses run parallel, or, where curved, evenly and uniformly to the curvature of the work, and centres in neat, close, and regular joints struck neatly and flush with the face of the work. In the case of work built on centres the joints shall be carefully cleaned off and finished upon the removal of the centres.

The manholes shall be constructed with square chambers. The foundations and floors shall be formed in cement concrete, properly shaped to the forms shown on the drawing. The floors of the manholes shall be rendered 1 in. thick in cement mortar, the whole being carefully constructed to the exact forms and gradients shown on the drawings. Semi-circular channels shall be formed in the concrete floors, and where two or more sewers enter a manhole the channels shall be curved so as to lead the sewage from one sewer into another with as little interruption to the flow as possible.



3. BRICK GULLY TANK



4. GULLY, SHOWING KERB OVERFLOW

The walls and arches shall be built in brickwork and backed up behind solid with filling of approved material. The bricks shall be carefully cut and made good where the sewer pipes pass through.

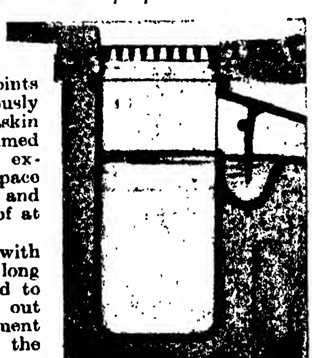
Every manhole shall have cast-iron plates inserted in the arches where they are cut away to form the entrance to the manholes.

The covers shall be of the patterns shown and described, and they shall be carefully set to the slope of the ground surface.

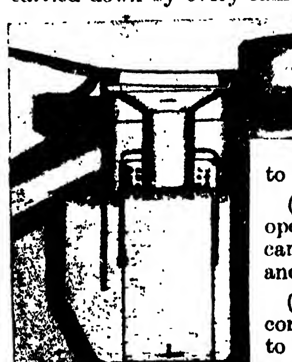
Foot-irons shall be inserted and fixed in every fourth course of the wall, extending through the brickwork, and turned up so that they cannot be drawn.

Gullies. For roads and streets where *paved* channels are formed, iron or stoneware gullies, covered with iron gratings and frames, are used. A great number of different descriptions and types of gullies are on the market, and it is impossible to go into the merits of all, but they should be of such form, materials, and dimensions as the necessities of the case require.

For country roads and by-roads, where cost is a consideration, a suitable brick tank [3] can be constructed to hold a considerable quantity of the silt or detritus, which is carried down by every rain off such roads.



5. KNOWLE'S STREET GULLY



6. DURRANT'S PATENT STREET GULLY

The form and size can be decided upon only by the necessities and requirements of each case. The principal objects to be considered are:

(*a*) Sufficient area of open grating surface to carry off heavy rains and storm water.

(*b*) Sufficient cubical contents of the gully to retain road detritus and silt below the outlet, to prevent their being carried by the water into the sewer.

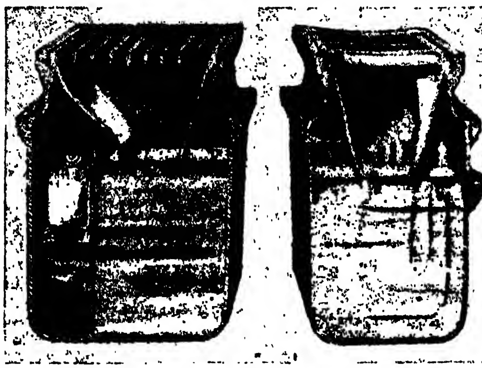
(*c*) A good water-seal or trap to prevent the escape of sewer gas.

The gully tanks should be carefully bedded and fixed in their position, and the connection to the drain-pipes made with a cement joint

The weir, or kerb overflow [4], is to be fixed

at such a height as to bone into the kerb height, and the channelling so arranged that the water may flow freely over the weir. The cover should be bedded on brickwork set in cement, and the top should be laid flush with the pavement. Figs. 5, 6, and 7 illustrate certain types of gullies, and show the manner in which they are fixed. Figs 8 and 9 illustrate gully gratings for brick and stoneware tanks.

Subways for Pipes. It is somewhat of a slur on our boasted twentieth century notions of sanitation that the pipes conveying pure water to the community should be allowed to be hidden, and, with a proportion of important fittings, to be beyond the proper inspection and supervision they should have, the only method of inspection, localising a leak, or making a new connection being to break open the public carriage-way.



7. CROSTA PATENT SURFACE WATER GULLY

London subways are the most complete of their kind in England, and are in size 16 ft. wide by 7 ft. 6 in. high, 12 ft. by 7 ft. 6 in., and 8 ft. by 7 ft. Nottingham has some most convenient subways, but nothing of the kind is to be found in Manchester, Liverpool, Birmingham, and other great centres, though, about 1895, the city engineer of Manchester prepared a scheme for subways under a section of new streets in that city at an estimated cost of £51,000 per mile.

Provincial Subways. In one of the principal subways in Nottingham the following pipes and cables are accommodated: One 15-in. sewer, two gas-mains about 8 in. diameter, two water-mains about 4 in. diameter, several telephone cables, telegraph cables, and twenty electric cables.

To show the value of such works, in Victoria Street, Nottingham, in which is situated the General Post Office, there are, besides the gas and water pipes and connections, no less than six pipes containing telegraph wires in the subway, and not one single stone was disturbed or the carriage-way broken up for twenty-five years, and in that period not one single penny was spent on repairs in that street.

8 AND 9. GULLY GRATINGS FOR BRICK AND STONEWARE TANKS

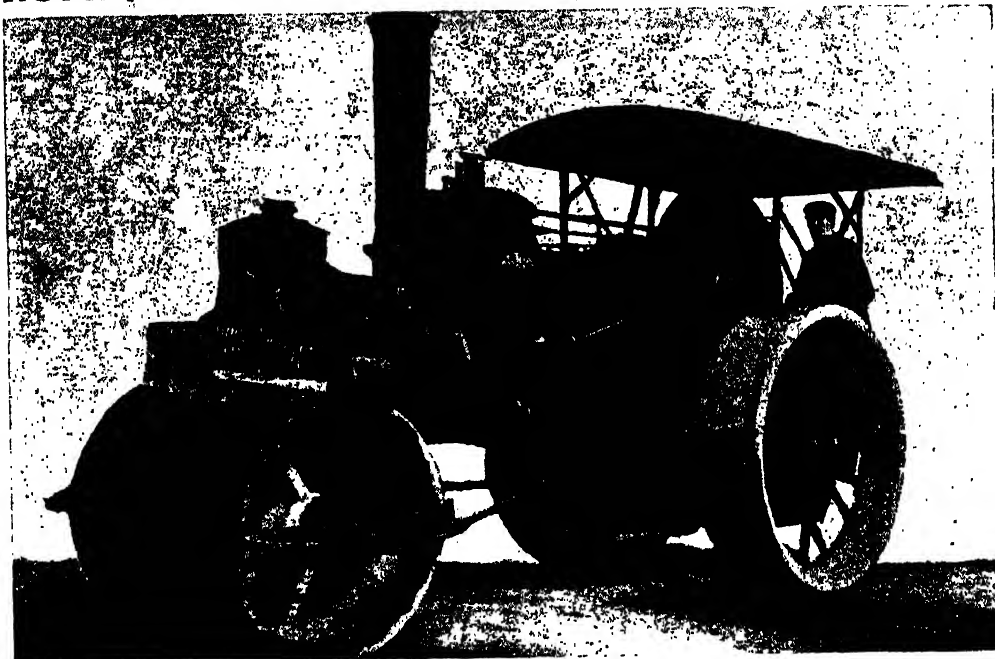
Visitors to St. Helens can hardly escape the conviction that there is one other borough in which experimental undertakings of subways are ventured upon.

It is, in fact, an agreeable surprise to find a comparatively small provincial town actually and successfully leading the way in an experiment which but a few years ago was often regarded with ridicule.

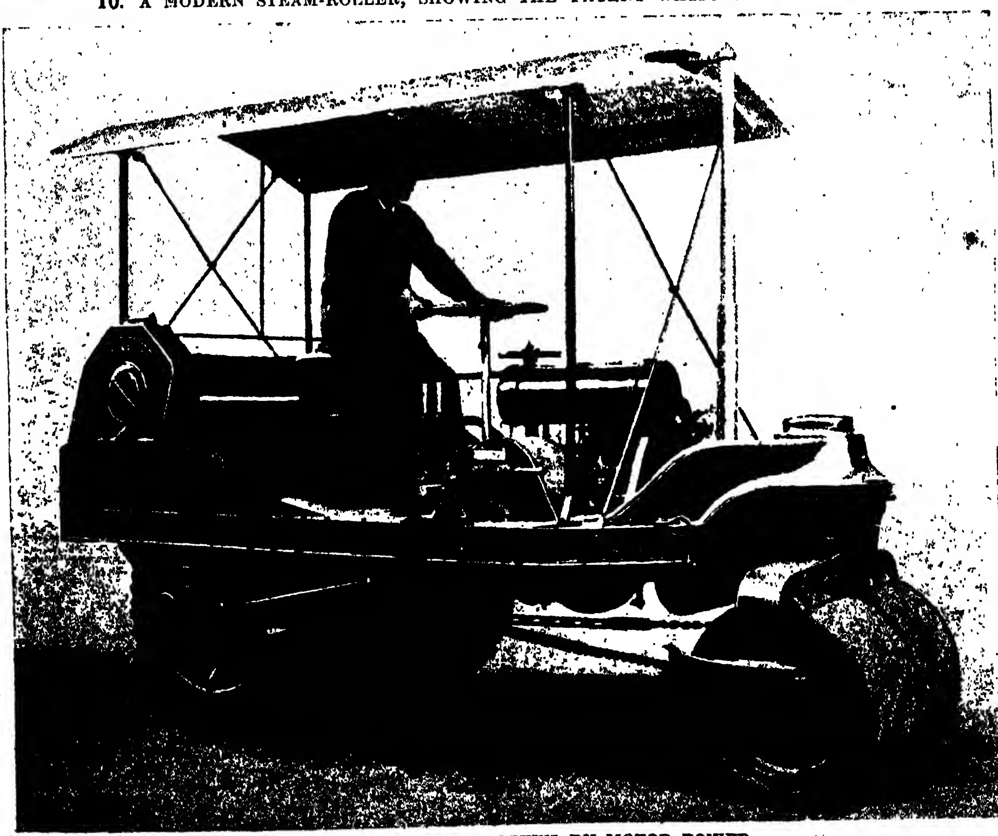
Construction and Cost. These subways are constructed wholly of concrete, with the exception of a $4\frac{1}{2}$ in. ring of brick to form the arch, and are 6 ft. 6 in. high by 5 ft. 6 in. wide, and contain one 18 in. gas-main, one 10 in., and one 6 in. water-main, with provision for telephone and electric light cables. The cost of these subways was £7 2s. 4d. per lineal yard, this amount including all the lateral ways and the electric lighting throughout.

Value of Subways. Not only is the result of cutting trenches longitudinally and transversely through the road detrimental to the road, but the contour is disfigured for a long time, and the necessary total or partial blocking up of a road necessitates pecuniary loss and delays to men of business. It is difficult fairly to estimate the loss through delay of traffic in the metropolis, and other large cities, caused by the opening of the roads, or to state the money that would annually be saved to the inhabitants by the adoption of some scheme for dealing with the existing pipes now buried, as any mode of estimation is ascertained on calculations of value on which opinions may differ, but the following rule-of-thumb calculations will verify that the loss is great: Allowing the 3022 omnibuses passing daily through the Strand to carry fifteen passengers each, we have a total per day of 45,000. A fair average per day of vehicles of all kinds passing through the Strand is 12,000, which leaves a balance of persons for carriages, cabs, and other vehicles of 9000. Allowing each to carry one person only, in addition to the driver, an addition of 18,000 persons is gained, making in all 63,000. Taking the delay caused to each vehicle in consequence of open pipe trenches to be three minutes, there is a loss of 3115 hours, which, at one shilling per hour, will realise £157 10s. attributed loss per day, or, in a year of 300 days, £47,250, which is the interest at 4 per cent. on a capital outlay of £1,181,250.

Steam Rolling. The invention of steam-rollers, so far as any practical results were obtained, was effected by Mr. William Clark, the city engineer of Calcutta, and the late Mr. Fothergill Batho, of Westminster, who took out a joint patent for a steam-roller in 1865. The



10. A MODERN STEAM-ROLLER, SHOWING THE PATENT WATERING ATTACHMENT



11. A ROAD-ROLLER DRIVEN BY MOTOR POWER

first constructed rollers were generally 15 tons in weight, although one of 30 tons was built for the Liverpool Corporation, and, although not used latterly, was broken up only in 1890.

In 1865 a trial was made in Hyde Park by Messrs. Aveling & Porter in steam-rolling. An ordinary traction-engine had its wheels exchanged for heavy and wide roller-wheels. The trial was considered a success, and the next improvement was the roller supplied by this firm in 1867 to Liverpool. A modern roller is illustrated in **10** and **13**.

Capacity of the Steam-Roller. By the use of steam-rollers some 2000 superficial yards per day can be efficiently rolled, at a total cost of one-third of a penny to one-fifth of a penny per sq. yd. By the use of the roller the road is made at once; the stones which compose it, while still sharp, are driven at once into their places, to the infinite comfort of the horses and men who have to traverse it.

A road properly rolled and consolidated will last 50 to 100 per cent. longer than an unrolled road, and will be much better able to withstand frost and heavy rains. The cost of haulage over its surface will be lower, and the amount of road detritus removed from it will be very much less.

It is generally recognised that in order to prevent the material (especially hoggin) from adhering to the wheels of steam-rollers a quantity of water has to be spread over the surface of the road which is greatly in excess of the amount which is necessary for the consolidation of the road, and that much better roads would be made if less water were used to keep the wheels of the roller wet.

A new spraying apparatus, recently invented by Mr. Ernest van Putten, borough engineer of Lewisham, entirely overcomes this trouble, and also effects a very considerable economy by dispensing with the necessity of a horse, driver, and water-cart in attendance on each steam-roller. It also reduces the cost of water.

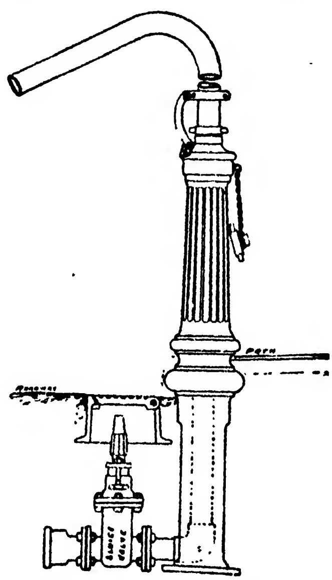
Water in any quantity desired is forced from the water-tank by an ejector through copper tubes, and sprayed through perforated pipes over the wheels. It is controlled from the footplate by the driver, by taps arranged in such a way that any one, two, or three wheels may be sprayed at a time. The supply can be so regulated that it may come drop by drop or in sufficient quantity to consolidate a road in hot, dry weather [10].

It is now nine years since Messrs. Barford & Perkins, of Peterborough, originated the motor-roller, and eight years since the first one offered to the public was exhibited and sold. This roller has been, and is still, in regular use in Surrey; and the small cost of its maintenance and working, together with its manifest utility, is proof that its design and manufacture were on sound engineering lines.

A roller of this type has been in regular use since 1905 by the War Department of the British Government for making and repairing asphalt, tar macadam, and other paths. The Government has since bought a large number of these rollers of heavier sizes for road-making at home and abroad.

Ten 14-ton machines (these are the internal-combustion, equivalent to the standard type of steam-roller) are at work on the new Turkish national roads, which are being constructed by contract. The cost of a motor-roller, as illustrated, complete with awning, paraffin carburetter, and connections, is approximately £400 [11].

The Local Government Board sanctions loans to urban and rural district councils for the purchase of rollers, spreading the payment over ten years.



12. STREET HYDRANT FOR FILLING WATER-CARTS

Watering. Roads are sprinkled with water during the dry season for the purpose of supplying moisture essential to ensure the best wearing results from macadamised roads.

The water is usually distributed by water-carts, a two-wheel cart holding from 220 to 300 gallons, and a four-wheel van 400 to 450 gallons, the carts being filled from street hydrants [12]. In Paris, and a few towns in this country, watering is frequently done by hose attached to the fire hydrants in the street. Metal pipes with flexible joints are generally adopted; or, if hose-pipe is used, it should be protected by a coil of thick wire. Ordinary hose-pipe, owing to the severe friction it receives, soon wears out. The hose method is not to be recommended in preference to the use of water-carts.

Sea-water for road-watering has been largely employed during recent years in seaside towns. Salt water for this purpose has some advantages over fresh. There is a considerable saving in the cost of sprinkling by the use of salt water when it is near at hand as compared with that of fresh; one sprinkling of the former will lay the dust for a length of time that would almost require two or three sprinklings of the latter. A road, after being sprinkled once or twice with sea-water, will remain free from dust for some time after the road is practically dry, as the deliquescent salts contained in the water form a hard crust which in a measure preserves the surface.

Channelling and Kerbing. Channelling, also known under the technical term of *gutter and water tables*, is essential for all roads, to carry away the water.

All channels should be from 12 to 18 in. wide, and laid on a 4 in. concrete foundation, and well grouted in with liquid Portland cement or cement and sand.

Channels are usually constructed of granite, either 12 in. flat or with 3 in. setts laid in courses to form a 9, 12, 15, or 18 in. channel.

Three inches should be the minimum thickness for any class of street. At the crossings or intersections of streets it is advisable to keep the channel level with the kerb, to enable pedestrians to step off the path on to the crossing without a drop. This can be readily done by using granite pitchers around the corner, and allowing one edge of the pitchers to butt against the kerb, the other edge of the pitchers tilting towards the crossing, as it is very seldom that water has to be carried at these points.

Materials used. The chief granites used are Aberdeen, Guernsey, and Norwegian, costing 2s. to 2s. 4d. per lineal foot, 4 in. in thickness, 12 in. wide on a concrete foundation, and stones—Keinton, Purbeck, and Shamrock—of the same dimensions, costing 1s. 6d. to 1s. 10d.

All footpaths should have a kerb on the outer edge to act as a sill for raising the path above the water flowing along the channel, and to retain the foundation and surface of the path.

The most usual kerb is a dressed granite, such as an Aberdeen, Guernsey, or Norwegian, 12 in. wide by 6 in. deep, costing from 2s. to 2s. 6d. per lineal foot, laid complete on a concrete foundation, though in a country district an undressed granite, 4 in. wide by 9 in. deep, costing from 1s. to 1s. 6d. per lineal foot, may be substituted, but this certainly looks a little rustic, and has not the workmanlike appearance of a dressed kerb.

Kerbs are also made in blue Staffordshire stoneware, in either a bull-nosed, splayed, O.G., or solid pattern of various sizes. A kerb can also be constructed of cement concrete blocks, or with concrete *in situ*, by means of plank moulding rigidly fixed in place, and removed after the concrete has set. This kerb is suitable for a street of poor-class property, where it is essential to study economy.

The concrete should be of the best materials, such as good Portland cement and thoroughly clean shingle, ballast, or broken stone in proper proportion and well mixed. In France wrought and cast iron kerbs are used, and these have recently been introduced in some towns in England. In America fireclay brick kerbs of various shape have been used with success.

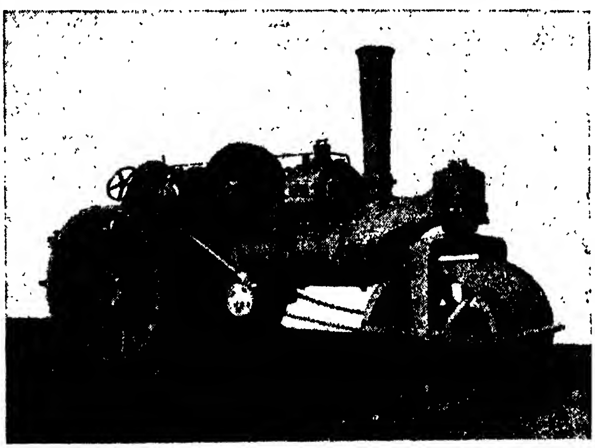
In laying kerb it is very important that an experienced man possessing a good eye should be employed to make it appear pleasing to the eye, both as regards line and level, as kerb laid even a little unevenly is very perceptible. The "skillet line" and "boning rods" are used to assist in securing a straight or curved line. It has been held that a local authority has no power to compel the kerb of a footpath to be laid in a new street before building operations are begun.

Specification. The following is an abbreviated clause for the specification:

Lay the granite kerb in a dead straight line, with uniform longitudinal gradients, and so as to bone accurately through from point to point. The kerb is to be laid on 4 in. of cement concrete, 15 in. wide, with a fall of ½ in. outwards toward the channel, each stone to be embedded solid and well beetled down into position with close butt joints.

The butt joints are to be well grouted in with one part of cement to two parts of fine sand, each joint to be completely filled and finished with a neatly cut joint.

The channelling is to be laid on 4 in. cement concrete, 12 in. wide, to uniform gradients 4 in. below the top edge of the kerb, except where otherwise specified or directed by the engineer, and with a cross fall of 1 in. toward the kerb, each stone bedded solid and well beetled down into position with close joints.



13. A MODERN STEAM-ROLLER

The butt joints and the joint between kerb and channel are to be grouted in and finished as specified for the kerbing. All channelling is to be laid so as to break joint with the kerbstones. A circular kerb is to be accurately laid in the position shown upon the drawings, so as to continue the line of kerbing in a uniform curve of proper radius, with proper radiating joints, which are to be accurately fitted on the spot if necessary.

Where kerb has to be relaid it is to be carefully taken up and relaid on concrete in the manner described for new kerbs, and lowered or raised to new level as required.

Any existing kerbstone which the surveyor may deem unsound or defective are not to be reused. The contractor is to include in his price for reworking, back-jointing, and squaring ends of any kerbs which have to be relaid.

All gully tanks to be supplied with 6 in. outlet and movable grating of strong bars, each grating to weigh not less than 2 cwt. 25 lb.

A row of granite setts laid as headers on cement concrete 4 in. in depth, and grouted as specified in the paragraph above relating to channelling, to be laid around all gully gratings, and splayed at each end to meet the water channel.

This specification, if properly carried out, should ensure a thoroughly satisfactory kerbing and channelling. Of course, all kerbing and channelling should be laid previous to the formation of the carriage-way.

A. TAYLOR ALLEN

**Short Studies of Defoe, Swift, Steele, and Addison.
The Influence of "The Spectator" and "The Tatler."**

EIGHTEENTH CENTURY PROSE

What the prose of the eighteenth century may lack in colour and warmth as compared with the prose of the seventeenth century it gains in general smoothness, perspicacity, and correctness. It set the standard of the prose of the present day. It has been styled "aristocratic," and this description is in the main a true one. But at the period with which we are now to deal the "aristocracy of intellect" was to a great extent employed to the furtherance of ends more practical, or at least more partisan, than literary. These ends were in part political, in part ecclesiastical, in part ethical. Thus the literature of the time must be studied in connection with its political, religious, and social history.

Daniel Defoe. To Daniel Defoe (b. 1661 ? ; d. 1731) must be assigned distinction as the first of English journalists, and as the forerunner of Richardson and Fielding. Today, save as the author of two or three books, one of them of world-wide repute, Defoe is half forgotten. In his lifetime, however, he played many parts, and over 250 distinct works bear his name. His "Robinson Crusoe" is as immortal as "The Pilgrim's Progress" or "Don Quixote." Like these two works and one other that we shall have to mention almost immediately, "Robinson Crusoe" may be read by the young on account of the narrative alone, and by elder readers as an allegory. Of the many pamphlets that flowed from Defoe's busy pen the most remarkable, perhaps, is that bearing the title "The Shortest Way with the Dissenters," a Whig production, the plausible realism rather than the satire of which secured its author a cell in Newgate and a place in the pillory.

As the author of "Captain Singleton," "Moll Flanders," "Colonel Jack," and other works of a kindred character, Defoe stood sponsor to the novel of crime. In 1704 he started a "Review" which was the forerunner of "The Tatler," "The Spectator," and "The Rambler." "Robinson Crusoe" and the fictitious "Journal of the Plague Year" are enough to secure for Defoe pre-eminence as a master of the art of literary illusion. "To him," says Leslie Stephen, "was given a tongue to which no one could listen without believing every word he uttered." He had defects. He was curiously heedless of chronology; he was weak, on the whole, as a delineator of character. But he was an essential "realist;" and if his readers would study the didactic side of his writings more, and the "Serious Reflections" of his inimitable hero in particular, the character of Defoe himself would escape in the future some at least of the aspersions that are still cast upon it.

No one need be counselled to read "Robinson Crusoe." The reading of this immortal fiction is in the birthright of every Englishman, though not so many are familiar with its sequel, which, not lacking in interest, is yet greatly inferior to the first and ever-popular story. "Moll Flanders" ought certainly to be read, and "The Journal of the Plague," and we would also urge the claims of "Colonel Jack," which contains some of Defoe's most brilliant writing.

Jonathan Swift. As a pamphleteer Jonathan Swift (b. 1667 ; d. 1745) affords an interesting companion study to Daniel Defoe. Swift was, however, by far the greater man. His power as a pamphleteer may be gauged by a consideration of the famous "Letters," signed "M.B., Drapier," and familiarly known as "Drapier's Letters." In these compositions he attacked the iniquitous "job" by which, in 1722, a certain William Wood, a hardwareman and a bankrupt, was granted a patent for supplying Ireland with copper coin. The "Drapier Letters" defeated this project; and though it is often said that the ensuing popularity of their author among the Irish people was unpalatable to him, his bequests to Irish charities seem to negative the idea that he had no sympathy for the people amid whom his lot was for a long time cast.

Swift, it is to be feared, is largely misunderstood. Though he became a keen Tory, his indignant passion against wrongdoing raised him so much above party feeling that he offended both friends and enemies. What he scorned to do for the sake of party or for the sake of his own preferment, he scorned to do for the sake of being thought conventional in his language. The result has been misunderstanding and the keeping of admiration at arm's length. The "Tale of a Tub" is the most comprehensive example of all that is characteristic of his prose style. As sailors were supposed to throw out a tub to a whale to prevent it from colliding with their ship, so Swift thought by his "Tale" to afford such temporary diversion to the wits and freethinkers of his day as to prevent them from injuring the State by the propagation of wild theories respecting religion and politics. But his satiric genius, his fiery imagination, and his keen eye for "the seamy side" imparted to the "Tale of a Tub" qualities that disguised his avowed object, and at the very outset placed an insurmountable obstacle in the way of his ecclesiastical preferment.

Satire and Self-revelation. "The Battle of the Books," which, with the "Tale of a Tub," helped to make Swift famous, takes a witty part in a controversy that was raging over

the respective claims of modern and ancient literature. Something like one-fourth of Swift's most remarkable work, "Gulliver's Travels," and a great part of his other writings, are debarred from general circulation on account of their coarseness. But of "Gulliver's Travels" enough is so delightful as romance as to rival both "Robinson Crusoe" and "The Pilgrim's Progress" in the estimation of young and old. Important as a satire, "Gulliver's Travels" has a distinct value as autobiography. While Defoe excelled in the art of making fiction read like fact, Swift, with the finest skill, cultivated a drastic simplicity and homeliness of style the accumulated effect of which was so formidable as to afford a permanent object-lesson in the art that conceals art where the writing of nervous English prose is concerned. But the fact must not be ignored that with all its carefully calculated simplicity the English of Jonathan Swift is never pedestrian or devoid of sparkle or variety. We select as an illustration of Swift's style his "Meditation upon a Broomstick," in which he imitated the manner of the "Reflections" of the philosopher Robert Boyle. It was written for a lady who greatly admired these meditations.

Specimen of Swift's Prose. "This single stick, which you now behold ingloriously lying in that neglected corner, I once knew in a flourishing state in a forest. It was full of sap, full of leaves, and full of boughs. But now in vain does the busy art of man pretend to vie with Nature by tying that withered bundle of twigs to its sapless trunk! 'Tis now at best but the reverse of what it was, a tree turned upside down, the branches on the earth, and the root in the air. 'Tis now handled by every dirty wench, condemned to do her drudgery, and, by a capricious kind of fate, destined to make other things clean, and to be nasty itself. At length, worn to the stumps in the service of the maids, 'tis either thrown out of doors or condemned to the last use of kindling a fire. When I beheld this I sighed, and said to myself, *Surely mortal man is a broomstick.* Nature sent him into the world strong and lusty, in a thriving condition, wearing his own hair on his head, the proper branches of this reasoning vegetable, till the axe of intemperance has lopped off his green boughs and left him a withered trunk. He then flies to art, and puts on a periwig, valuing himself upon an unnatural bundle of hairs, all covered with powder, that never grew on his head. But now should this our broomstick pretend to enter the scene, proud of those birchen spoils it never bore, and all covered with dust, though the sweepings of the finest lady's chamber, we should be apt to ridicule and despise its vanity. Partial judges that we are of our own excellencies, and other men's defaults! But a broomstick, perhaps you will say, is an emblem of a tree standing on its head; and pray what is man but a topsy-turvy creature, his animal faculties perpetually mounted on his rational, his head where his heels should be, grovelling on the earth! And yet, with all his faults, he sets up to be a universal reformer and corrector of abuses, a remover of grievances, rakes into every slut's corner of Nature, bringing hidden corruptions to the light, and raises a mighty dust where there was none before, sharing deeply all the while in the very same pollutions he pretends to sweep away. His last days are spent in slavery of women, and generally the least deserving; till, worn to the stumps, like his brother besom, he is either kicked out of doors or made use of to kindle flames for others to warm themselves by."

Steele and Addison. Sir Richard Steele (b. 1672; d. 1729), the friend and schoolfellow of Joseph Addison (b. 1672; d. 1719), was, like Swift, born in Ireland, but in this fact lies the sole resemblance between the saturnine Dean of St. Patrick's and the genial "scallywag" who originated "The Tatler," wrote part of "The Spectator," founded "The Guardian" and other ephemeral periodicals, and worshipped Addison as a hero.

In 1709, Steele started "The Tatler" anonymously. It was a small sheet, sold for a penny, appearing three times a week, and designed to expose "the false arts of life, to pull off the disguises of cunning, vanity, and affectation, and to recommend a general simplicity in our dress, our discourse, and our behaviour." Part of "The Tatler" was devoted to news. When his pen-name of Isaac Bickerstaff, which he borrowed from a diverting pamphlet by Swift, became useless as a disguise, Steele founded "The Spectator." "The Tatler" extended to 271 numbers, of which Steele wrote 188; his friend Addison contributed 42, and they were jointly responsible for 36. "The Spectator," which was published daily, ran to 635 numbers, of which Addison wrote 274 and Steele 240. The wholesome effect of these publications on the manners and morals of the eighteenth century can hardly be exaggerated. Both the style of writing and the tone of conversation were improved as a result of their influence.

It is generally conceded that while Addison's style is the more finished, Steele's is more marked by liveliness of invention. Addison usually wrote at leisure, Steele often in a "white heat." The papers took the form sometimes of moral and critical discourses, sometimes of short stories of domestic life, in the writing of which Steele excelled.

Influence of Steele and Addison. Both "The Tatler" and "The Spectator" are remarkable for the respectful tone adopted in referring to women, though Steele was more chivalrous and less patronising than his friend. It was in "The Tatler" that, as Mr. G. A. Aitken reminds us, Steele wrote, "As charity is esteemed a conjunction of the good qualities necessary to a virtuous man, so love is the happy composition of all the accomplishments that make a fine gentleman." And in the same paper he paid his memorable tribute to Lady Elizabeth Hastings (b. 1682; d. 1739), a philanthropist and beauty, immortalised as "Aspasia" by both Steele and Congreve: "Though her mien carries much more invitation than command, to behold her is an immediate check to loose behaviour, and to love her is a liberal education."

The plan of "The Spectator" was laid at a club, and in the second number, written by Steele, we are given the first sketches of the members.

It is, as Mr. Aitken observes, a remarkable testimony to the skill of Steele's work that the characters stand out so clearly before us. The immortal baronet Sir Roger de Coverley is understood to be Addison's invention. "The great work of Addison and Steele was to form public opinion on matters respecting which it can hardly be said to have existed before, and to cause their readers, at a critical time in our history, to consider moral and social questions from a higher standpoint than had been their wont." As a short example of Steele's style, we may select the following passage on a theme that is of universal interest.

Example of Steele's Style. "The first sense of sorrow I ever knew was upon the death of my father, at which time I was not quite five years of age: but I was rather amazed at what all the house meant than possessed of a real understanding why nobody was willing to play with me. I remember I went into the room where his body lay, and my mother sat weeping alone by it. I had my battledore in my hand, and fell a-beating the coffin, and calling Papa; for, I know not how, I had some slight idea that he was locked up there. My mother caught me in her arms, and, transported beyond all patience of the silent grief she was before in, she almost smothered me in her embrace, and told me, in a flood of tears, papa could not hear me, and would play with me no more, for they were going to put him underground, whence he could never come to us again. She was a very beautiful woman, of a noble spirit, and there was a dignity in her grief amidst all the wildness of her transport, which, methought, struck me with an instinct of sorrow, which, before I was sensible of what it was to grieve, seized my very soul, and has made pity the weakness of my heart ever since."

Steele and Addison Compared. Steele, as Hazlitt remarked, seems to have gone into his study chiefly to set down what he observed out of doors. Addison, on the other hand, drew most of his inspiration from books. But whatever the cause may be, and however much our heart may go out to "Dick" Steele, the verdict of such good critics as Johnson and Macaulay must be accepted concerning the high qualities of Addison's limpid style. Addison's sentences, according to Johnson, have neither studied amplitude nor affected brevity; his periods, though not diligently rounded, are voluble and easy. "Never," said Macaulay, "had the English language been written with such sweetness, grace, and facility."

Steele excelled in sympathy. Addison was a master of irony. Not the least of Addison's services to literature was the attention he gave in "The Spectator" to Milton. These papers should be studied by all who desire to appreciate the style and value of literary criticism in Addison's time. On the whole, we read Addison today not so much for the value of what he has to say as for the way in which he says it. One of the most noteworthy of his contributions to "The Spectator" is the allegory entitled "The Vision of Mirza," which the writer professes to have translated from an Oriental manuscript. It tells of one who went up to the high hills of Bagdat to pray. There he met the Genius of a certain rock who opened his eyes to the vision of a great valley with a prodigious tide flowing through it. The valley is the Vale of Misery, the tide part of the great Tide of Eternity. In the midst is a Bridge—Human Life—over which multitudes are passing, and which, like the valley, is shrouded at both ends by darkness. The fairway is studded with trap-doors through which passengers fall into the flowing tide beneath.

Short Specimen of Addison's Style. "The Genius, being moved with compassion towards me, bid me quit so uncomfortable a prospect. Look no more, said he, on man in the First Stage of his Existence, in his setting out for Eternity; but cast thine eye into that thick Mist into which the Tide bears the several generations of mortals that fall into it. I directed my sight as I was ordered, and (whether or no the good Genius strengthened it with any supernatural force, or dissipated part of the Mist that was before too thick for the eye to penetrate) I saw the Valley opening at the farther end, and spreading forth into an immense Ocean that had a huge Rock of Adamant running through the midst of it, and dividing it into two equal parts. The Clouds still rested on one half of it, inasmuch that I could discover nothing in it; but the other appeared to me a vast Ocean planted with innumerable Islands, that were covered with fruits and flowers, and interwoven with a thousand little Shining Seas that ran among them. I could see Persons dressed in glorious habits, with garlands upon their heads, passing among the trees, lying down by the side of fountains, or resting in beds of flowers; and could hear a confused harmony of singing birds, falling waters, human voices, and musical instruments. Gladness grew in me upon the discovery of so delightful a scene. I wished for the wings of an eagle that I might fly away to those happy seats; but the Genius told me there was no passage to them, except through the Gates of Death, that I saw opening every moment upon the Bridge."

Addison's Merits and Defects. This is no bad specimen of Addison's style, illustrating its defects as well as its merits. He sacrificed everything to elegance; that is, to rhythm or melody of phrase. The supple movement and cadence of the above, its colour, will be at once apparent. Still, Addison not only shows a somewhat limited vocabulary at times, but is very apt to repeat unnecessarily his ideas and his images. The allegory from which we have quoted will furnish examples of this, and also of what is not always a fault, though usually stigmatised as such by the partisans of the pompous, rhetorical style of prose—his looseness of construction. In the essay, this has its advantages, and helps to lightness of touch, which is scarcely possible where the writer aims at "rounded periods" or stately sentences.

J. A. HAMMERTON

Positions on the Non-resident and Resident Staffs. Clerks and Relieving Officers. Masters, Matrons, Stewards, and Storekeepers.

POOR LAW APPOINTMENTS

Clerk to the Guardians. This, the foremost office on the Poor Law staff, may fairly be compared in more than one respect with that of town clerk. Like the latter official, the clerk to the guardians is at once head of the executive and adviser to his authority. In both capacities his duties are very important. It must be remembered that the board of guardians is an association of amateur administrators; and that while its members are for the most part properly equipped for their tasks, instances of prejudice, misconceived powers, and mistaken zeal are not unknown among them. Naturally, the difficulties arising in the administration of poor relief are, in the main, legal. This work is governed by a complexity of statutes, Local Government Board orders and circulars, official precedents, and decided cases; and with the risk of surcharges always present, it is a responsible and difficult task to pilot the board of guardians in safety through its many functions. To take but a single instance, the question of "settlements"—which consists in determining the parish or union to which a pauper is properly chargeable—presents some of the knottiest problems that ever gladdened the heart of a lawyer.

The Need for a Legal Training. Hence it is that some sort of specialised legal training, whether professional or not, is almost as indispensable for the position of clerk to the guardians as is a wide experience of Poor Law methods and practice. We may rank as next in importance a thorough knowledge of rating and assessment work. During recent years there has been a growing tendency on the part of the authorities to select for their leading official a solicitor or barrister who is well versed in each of the above requirements, but the proportion of professional men in the service of the guardians is still small. A non-professional appointment made by a northern board will illustrate the class of training that is likely to stand a candidate in good stead. The record of the officer selected as clerk included 11 years spent in a solicitor's office and 15 years' valuable experience in the assessment of property and the details of rating, acquired in the double capacity of assessor of income and assistant overseer.

The Best Training School. A census of guardians' clerks throughout the country would demonstrate that the majority of them qualified for their positions by years of service under the guardians in the capacity of assistant clerk. The best school for candidates is to be found in the office of a clerk to the guardians of a busy area who is himself a solicitor. A stern critic of our Poor Law service has complained at "the system of hereditary succession often prevails in it, as in the case of French executioners under the old régime." Local influence often counts for a good deal in the contest for a chief clerkship, although exerted in the direction of official rather than hereditary succession. But the Poor Law service is not the only one in which the reversion of the leading rôle oftenest falls to the understudy.

Salaries and Emoluments. As is inevitable among authorities of such widely differing importance, the remuneration of clerks to the guardians varies greatly. In a small rural union the salary is usually fixed at a figure between £180 and £300 a year. On the other hand, in a busy city or a metropolitan union it may be anywhere within the limits of £400 and £1000. The clerk to a northern London board, for instance, has received first £500, then £650, and afterwards £850 a year. Those amounts, however, covered the salaries of any assistants employed by him. The Sheffield guardians pay their clerk £650 a year, rising to £700; and this is typical of the salary in the larger unions.

The actual salary attached to a clerkship *as such* seldom represents the full fruits of the position. The clerk to the guardians often holds several minor appointments in addition, the rewards from which add considerably to his income as clerk, and may even double it.

Thus the clerk to a small provincial union at £200 a year receives approximately an equal amount as superintendent registrar of births, etc.; £35 a year for his services under the assessment committee, and, in addition (being under no restrictions as to other work), is clerk to the local district council at a salary of £255—a total income of nearly £700 a year. It will be evident, therefore, that the office of guardians' clerk is often a very lucrative one.

Assistant Clerks. The staff of subordinate clerks is small. It ranges from a junior at £40 or £50 a year up to the first assistant clerk, whose pay may reach £350, but is more often between £150 and £275. The number of intermediate posts is naturally determined by the importance of the union. Concerning the prospects of senior assistants, there is nothing to add to what has been said in discussing principal appointments. Their practical training should have special reference to Poor Law accounts and the law of settlement and removal, and can be gained only in a guardians' office.

The Relieving Officer. "The pivot of a well-administered Poor Law," says a distinguished authority, "is an intelligent, sympathetic, and high-minded relieving officer." Without undervaluing the services of the indoor staff, most persons who are in touch with the

difficult problems of poor relief will be inclined to echo this dictum.

The peculiar importance of this public servant's duties is explained by the fact that he has to investigate the cases of all applicants for relief, and to lay before the board or committee a report of their health, circumstances, character, and ability to work. The guardians personally know nothing, as a rule, of the facts concerning these applicants. They rely on their expert to ascertain those facts; and upon his report and advice their action in dealing with each request for aid mainly and necessarily depends. Now, the essence of effective relief is a wise discrimination between the various classes of applicants. The indolent and vicious must be sternly dealt with, the unfortunate aided, the infirm provided with a shelter—always avoiding the extinction of self-reliance and the fostering of a pauper spirit. If, therefore, the relief administered is to prove helpful and not harmful, the relieving officer must be a shrewd, kindly man, neither credulous nor routine-bound, and his reports must be full, impartial, and suggestive.

An Official Man-of-all-Work. The relieving officer, with or without assistants, is generally placed in charge of a Poor Law district, within which he must reside. His duties, which are regulated by orders of the central authority, are of a very varied character. In addition to the work already mentioned they include the granting of temporary relief in urgent cases, and of provisional orders for the workhouse; placing lunatics under restraint, and transferring to their place of settlement paupers belonging to other unions. The relieving officer has also to call in the district medical officer and nurse when occasion arises, and to take out-relief to the poor who are too ill or feeble to call for it.

Qualifications. No officially recognised school of instruction for these posts at present exists, and the majority of candidates enter the service without any real knowledge of their work, picking up such information casually and piecemeal after appointment. There are many objections to this method, and it is fortunate that the National Poor Law Officers' Association affords special facilities enabling a would-be officer to learn something of his duties beforehand. The Poor Law Examinations Board, also, holds yearly tests in the proficiency of workhouse officers and of relieving officers; and although these examinations are purely voluntary, the certificates are already in high esteem, and may ultimately become compulsory for all higher posts. The best practical training is afforded by a subordinate or assistant position under an able and zealous officer.

Candidates are usually required to be over 25 and under 40 years of age, the upper limit being sometimes reduced to 35. A medical examination is generally compulsory; and as relieving officers hold money of the guardians in trust, a common condition of appointment is that security shall be found in £100.

Rates of Pay. Superintendent positions command from £220 to £250 a year, and occasionally £50 more. Apart from these, the range of a relieving officer's earnings lies within the limits of £100 and £200. A post of average value would begin with about £120 a year, and advance to £150 or a little more. London salaries, however, are on a slightly higher general level. In the City, for instance, district relieving officers begin at £160 and rise to £200. On the other hand, a good many rural boards are unable to pay more than £80 or £90 a year for relief work, but in such cases the officer's income is usually raised to about £125 at least by other emoluments. These include the appointments of registrar of births and deaths, vaccination officer, and collector to the guardians—all of them being Poor Law posts, and a small stipend being attached to each. Candidates without previous knowledge of relief work must generally be content to enter as assistant relieving officers at £80 or £100 a year, until qualified by experience for a better position. There is a growing tendency to appoint women as assistant relieving officers, at a stipend varying between £80 and £120 a year, or occasionally more.

Other Posts. In busy districts, separate appointments are generally made to the posts of collector and vaccination officer. The collector in such cases usually receives either 10 per cent. of the sums he recovers for the guardians, or a fixed salary of £100 or £120 a year, and a commission of 5 per cent. in addition. Vaccination officers are paid for each case of successful vaccination according to a scale of fees prescribed by the Local Government Board. Under a London board of guardians, such fees may amount to £130 a year or more. Officials of these two grades are frequently allowed to undertake other work during their spare time.

Certain emoluments accompany the salaries paid to all resident officers of the guardians and of similar authorities. As a rule, the indoor staff are provided with free rations, furnished or unfurnished apartments, lights and washing. Matrons, nurses, porters, and attendants are also entitled to their uniforms; and in many instances the subordinate officers have the option of an annual allowance of £3 or £4 in lieu of intoxicants. The lodging accommodation provided varies in value with the status of the official. The scale of rations is fixed in each parish or union by the guardians.

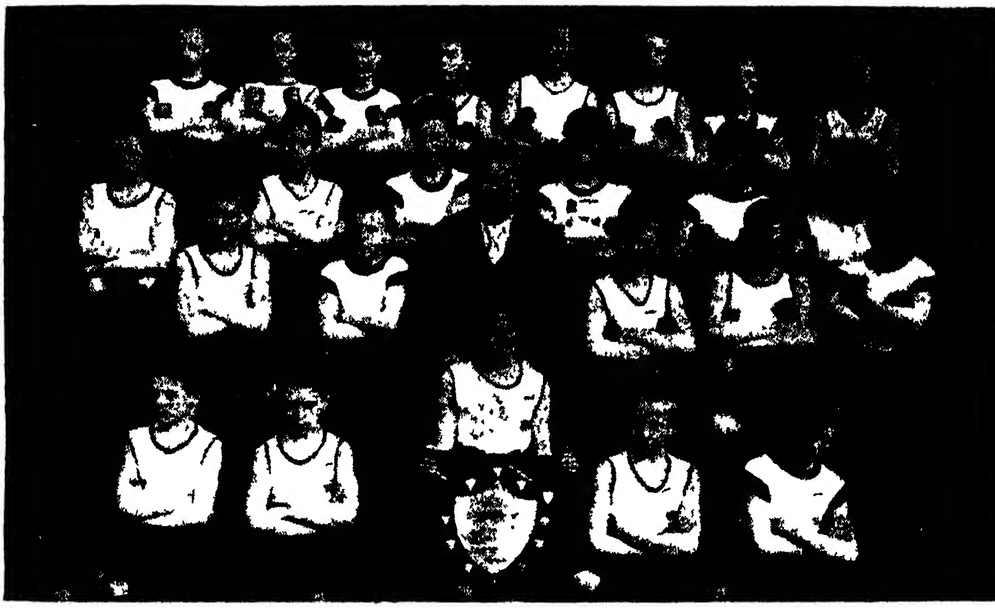
The Workhouse Staff. The recognised heads of the workhouse, on their respective sides, are the master and matron. They exercise general supervision and control over officers and paupers alike, and are answerable for the safety of the guardians' property, the due performance by every inmate of his or her daily task, and the proper conduct of the whole institution. Their duties are elaborately laid down by the General Consolidated Order of 1847. In the words of a Poor Law expert: "The management of the workhouse is in the hands of the master and matron, whose duties are set forth in the regulations in the minutest detail,

from the daily reading of prayers and saying grace before and after meals, to the cooking and distribution of the food, the general inspection of the wards, and the maintenance of order amongst the inmates. The temperature of the water for the baths is even laid down in the rules."

Salaries of Chief Officers. Without further instances of their multifarious duties, it will be readily understood that the master and matron of a workhouse are busy, responsible, and often much-harassed officials. Their work requires good organising powers, energy, and discretion, and a sound knowledge of all the complexities of Poor Law administration and accounts. The incomes with which these qualities are rewarded cannot be said to err on the side of generosity. For the larger unions, the joint earnings of master and matron usually amount to £200 or £250 a year, with emoluments computed at from £70 to £120 extra in all. In smaller institutions the total income, excluding allowances, varies between £175 and £80.

Previous experience of Poor Law work in some capacity is practically essential for these positions. Hence, they are generally filled by the selection of an assistant master and matron, a relieving officer and his wife, or the superintendent and matron of a casual ward. In more than one recent instance a married couple beginning their Poor Law service as porter and porteress have ultimately attained control of an important workhouse. As a rule, the master and matron are chosen from among applicants between 30 and 45 or 50 years of age, who either are childless or have only a small family.

Subordinate Officers. Assistant masters and masters' clerks are employed only in the larger institutions. A knowledge of the system of bookkeeping and accounts approved by the Local Government Board is a useful qualification for these offices, which command from £30 to £65 a year, with the usual extras, and are attractive chiefly as stepping-stones to a higher appointment. The positions of labour master and labour mistress, involving supervision of the able-bodied paupers during the performance of their daily tasks, are open to candidates who have no previous experience, but who can furnish proof of being good disciplinarians. For male officers, ex-sergeants and corporals of the Army are in request; while a knowledge of steam laundry-work is frequently a strong recommendation for the post of labour mistress. The limits of age are usually 25 to 40 for men, and 25 to 35 in the case of women. Masters are paid £30 to £36 a year, and mistresses about £5 less. The average rate of pay for yardsmen, wardsmen, and porters is £27 to £32 yearly. Apart from the ordinary domestic servants, these officials complete the executive staff. Every workhouse also has a small number of skilled operatives, including generally a fireman or engineer at £80 or £90 a year; a baker, receiving £60 or £65; a tailor, shoemaker, and male cook, each earning about £1 a week; and laundresses, at £25 to £35 a year.



THE PLEASANT SIDE OF POOR LAW ADMINISTRATION—A GROUP OF ATHLETIC BOYS
From a photograph taken at the Chase Farm Schools of the Edmonton Union at Enfield.

The Casual Wards. These institutions are sometimes part of the workhouse itself, but often are at some distance from it. They are designed for the reception of tramps and other "casual paupers" of both sexes, and are in charge of a superintendent and matron, whose duty it is to give their squalid guests the lodging and scanty fare prescribed by the regulations, and to insist on the performance of a proper task of work in return. The qualifications required of these

officers, and their earnings, are practically those of the labour master and mistress, which have already been discussed. The London casual wards are controlled by the Metropolitan Asylums Board.

Stewards and Storekeepers. The terms on which these officers are employed in the larger institutions of the guardians are well exemplified by the following particulars respecting the Metropolitan Asylums Board, which are communicated by the clerk of that authority:

"Clerks and storekeepers and stewards may be properly classed together. Their pay ranges from 40s. a week, with no resident allowances, to £300 a year, with full allowances, according to the size of the institution to which they are attached, and the extent of their duties. These institutions vary from a convalescent home for 100 children, to an imbecile asylum for 2000 patients. No technical qualifications are required, but, other things being equal, a man with some experience of the Poor Law system of keeping accounts (which is special and rather complicated) would probably have some preference. The duties consist in keeping the books of account with regard to the institution, receiving and distributing all supplies and stores, acting as clerk to the institution, and of supervising to some extent certain of the male staff; and, in institutions to which land is attached, their duties embrace the control of the farming and other operations."

This section of the Metropolitan Asylums Board staff includes thirty-five principal posts and a considerable number of subordinate ones. An excellent way of entering is as steward's junior clerk. These officers, who must be not less than eighteen years of age on appointment, receive an initial salary of about £70 a year. Their duties afford the best of training for an assistant stewardship, which is remunerated with £100 a year, advancing by £10 annually to £140, as well as full indoor allowances. Thence, for a capable official, promotion to principal rank is assured.

Asylum Officials. Apart from medical billets (which were discussed in the previous chapter), municipal asylums furnish employment to a large staff of stewards, matrons, and subordinate officers. These posts are variously filled, some authorities advertising vacancies, and others adopting the system of a "waiting list." Candidates for service under a particular council should therefore ascertain from the clerk which of these methods is adopted.

The Asylums Committee of the London County Council, which controls ten large asylums, and may be taken as a typical authority, remunerates its officers on the following scale, an annual increment, up to the maximum salary, being given in every grade:

House steward, £260, rising by £15 to £360, with meals; clerk, £210 to £360; assistant clerk, £124 to £164; dispenser, £114 to £184; matron, £105 to £155; assistant matron (second class), £64, by £2 to £74; first class, £84 to £95; male attendant (second class), £31 to £43; first class, £40 to £53; head officer, £53 to £80; [illegible] attendant, in corresponding classes, £19 10s. to £28, £29 to £37, and £42 to £53; farm bailiff, £2 3s. to £2 11s. weekly, with a house; tailor and other workmen, 31s. to 39s.; male cook, £54 to £80; butcher, £55 to £75; gardener, 26s. to 31s., and a cottage.

In addition to their salaries, cooks and butchers are provided with meals free of charge, and clerks and dispensers with dinner only. Matrons of each class receive board, lodging and washing, and attendants the same advantages, with their uniforms, and good-conduct money besides up to £5 a year.

In connection with this service, it should be noted that the post of steward is generally filled by the promotion of asylum clerks, and that of matron from the assistants. Candidates for assistant clerkships are required to have some knowledge of accounts, and to understand the receipt and issue of stores. The higher grades of attendant are invariably recruited from the subordinate ranks. It is the Council's general practice to appoint second-class attendants from a list of suitable applicants, the age limit prescribed for men being 35 years or less, and for women 20 to 30 years. Preference is given to male candidates who are instrumentalists, or who can play cricket and football, and to women with a knowledge of music and singing. Dispensers should hold the minor certificate of the Pharmaceutical Society. A liberal pension scheme is in force for officers of all ranks.

Municipal hospitals are staffed in practically the same way as asylums, except that the attendants are replaced by a corresponding number of nurses. These officers, if admitted as probationers, receive from £15 to £24 yearly during training, and afterwards £35 to £45, in each case with full allowances in addition.

Schools and Cottage Homes. These special centres for pauper children form an invaluable means of rescuing young lives from the dismal associations of the workhouse. For our purposes, however, the union school may be dismissed in a few words. It is generally controlled by an experienced superintendent and matron—the latter in many instances a trained nurse—at a joint salary of £120 to £200, with apartments and other advantages. It has its own small staff of teachers, whose position is much like that of elementary school teachers under the County Council.

Cottage homes are practically Poor Law colonies, in wholesome surroundings far from the taint of cities. Each house has its quota of youngsters under the care of a foster-mother—often a kindly-natured widow—who, in return for wages of £20 or £25 a year and emoluments, cooks and washes for her adoptive family, and trains its girls in domestic ways. Sometimes a young or middle-aged married couple is in charge instead, in which case the husband's share is the care of the boys out of school hours, at a salary of some £30 or £35. For these posts experience of children is generally essential.

Our survey of the Municipal Service concluded, and we now turn to a new bra[illegible] of our subject—the National Service.

ERNEST A. CA[illegible]

The Long Struggle to Establish the Theory of Organic Evolution, and the Men Who Fought It.

THE GREAT WORK OF LAMARCK

We have now surveyed the whole known range of living beings, extinct and extant, vegetable and animal, from the ultra-microscopic "filter-passers" up to man himself. We have found, as an historical fact, that there has been a process of evolution. The theory of "special creation" does not need attack today, for it no longer exists. But our problems are all before us. We still have evolution to explain, and thence the future of life to predict. As Herbert Spencer once said, as the sphere of knowledge grows, its area of contact with the surrounding unknown grows also; the more we know, the more we realise we do not know. And, in this case, we can now afford to be quite undogmatic and moderate and free from bitterness, for the theory of evolution, and the right to inquire reverently and humbly into the laws of Nature, are no longer fighting for their lives, with their backs to the wall, against the theologians of the nineteenth century.

We *must* begin with a brief historical outline of the idea of evolution, leading up to the great figure of Lamarck, which now, after a century, is just beginning to assume its real and splendid proportions in the minds of biologists.

History of Organic Evolution. Organic evolution is not a "new-fangled" idea. It was believed and proclaimed by the founders and pioneers of Greek philosophy, such as Heracleitus. It lay at the very heart of the teaching of the Buddha, who was a contemporary of Heracleitus. Six centuries before the Christian era, the mighty Greek and the still mightier Indian prince were teaching the continuity and the orderly change which are exhibited everywhere in the living world.

A few centuries later we find Aristotle, the "Father of Natural History," studying and comparing the different forms of life as he knew them, and, amid a host of errors, yet asserting the truth of organic evolution. And with his name we may couple that of Lucretius, the Roman philosopher and poet, who wrote a famous poem "On the Nature of Things," in which he definitely adopted and illustrated the Greek ideas of evolution. But, by an event of tragic significance for the history of knowledge, the ancient philosophers and students of Nature were forgotten, and a legendary theory—of Babylonian origin, carried on by the Jews, and thence to Christianity—became established as authoritative and revealed truth.

The Views of Bruno. Here, however, we may simply ignore this and the other Creation myths, and proceed to trace the survival, or revival, of the ancient philosophy throughout the Dark Ages when ecclesiasticism and brutal superstition ruled Europe. In 1600 the Italian philosopher Giordano Bruno, a greater Lucretius, was murdered for his beliefs by the Church in Rome, on the spot where a statue to his immortal memory now stands. He taught the doctrine of organic evolution, and of Universal Mind as the Prime Mover of the spheres and the Animator of all living beings.

Immanuel Kant. More than a century later, the name of Immanuel Kant, the German philosopher (of partly Scottish descent), comes before us. He taught the doctrine of organic evolution, as also of evolution in the heavens—cosmic evolution, like Bruno before him. He observed how so many animals are built upon a *common plan*—as it verily seems to be—and wrote these words, remarkable indeed if we realise the state of thought at the time. The facts of comparative anatomy, he says, "strengthen the supposition that living beings have an actual blood-relationship, due to derivation from a common parent, a supposition which is arrived at by observation . . . extending from man down to the polyps, and from these even down to mosses and lichens, and arriving finally at raw matter, the lowest stage of Nature observable by us. From this raw matter and its forces, the whole apparatus of [living] Nature seems to have been derived, according to mechanical laws (such as those which resulted in the production of crystals); yet this apparatus, as seen in organic beings, is so incomprehensible to us that we feel ourselves compelled to conceive for it a different principle."

The student must not read these words with haste, as of merely "dry-as-dust" interest. They must be read and re-read, and the language must be appreciated. Kant was one of the few greatest thinkers of all time, and this quotation is worthy of him. Note what he declares: that organic evolution is the truth; that there has been "spontaneous generation," or continuous evolution of living beings from "raw" or unorganised matter; that the physical laws of Nature are observed in various forms and facts of living beings; and yet that the apparatus of living beings is such that we are required "to conceive for it a different principle"—an underlying spring or *first* thing, which is what principle means, that is *not mechanical.*

De Buffon's Teaching. Kant had a great French contemporary, the Comte de Buffon, one of the most assiduous and acute and original of all naturalists. He clearly saw and taught the fact of organic evolution. He even made suggestions as to affinities between species.

Buffon taught that the horse and the ass must have had a common ancestry, and he dared to

say the same for the ape and man. Beyond a doubt he was right in each case. And in one respect Buffon went a little further than Kant, who did not venture upon any scientific *explanation* of the tremendous fact of evolution which he asserted. Buffon placed the real causes of evolution *outside* the living being, and in this respect he was the forerunner of the whole mechanical school of evolutionists, and of all the explanations which try to do without the "different principle," not mechanical, which resides *within* the living being. Buffon thus suggests that living species have been and are being "perfected or degenerated by the great changes in land and sea, by the favours or disfavours of Nature, by food, by the prolonged influences of climate, contrary or favourable." We may well note these words of Buffon, in which he points to the importance of environment, as we now call it, and of nutrition. Later we shall have to ask whether the environment can conceivably change living beings so as to make them adapted to it, or whether adaptation does not originate in the living being, which *adapts itself* to its environment—not repeating the environment but replying to it, as Bergson says.

Erasmus Darwin. Erasmus Darwin, in this country, is worthy of honour as, not a great or original thinker, but a brave and useful follower of Buffon. It was no ordinary naturalist, no mere amateur, who could write such remarkable words as these, words which are just as significant for us today as when they were written:

"When we revolve in our minds the metamorphoses of animals, as from the tadpole to the frog; secondly, the changes produced by conditions of climate and of season, as in the sheep of warm climates being covered with hair instead of wool, and the hares and partridges of northern climates becoming white in winter; when, further, we observe the changes of structure produced by habit, as seen especially in men of different occupations, or the changes produced by artificial mutilation and pre-natal influences, as in the crossing of species and production of monsters; fourthly, when we observe the essential unity of plan in all warm-blooded animals, we are led to conclude that they have been alike produced from a similar living filament."

A Great Page in the History of Thought. In this passage, the Derby doctor evidently believes that there is reason in the view which asserts that use and habit in the parent produce corresponding effects in the offspring. This is a theory which was soon to receive much more prominence. Meanwhile, we must be sure to remember the name of Erasmus Darwin, the forerunner of organic evolution, so far as this country is concerned, and especially of his own illustrious grandson, Charles Darwin. Lastly, we should note that theories of organic evolution were being simultaneously put forth, not only in England by Eramus Darwin, and the naturalist Saint Hilaire in France, but by the mighty Goethe in Germany. These three, each from his own point of view, were all teaching organic evolution in the closing years of the eighteenth century.

With the utmost brevity, we are here recounting the story of one of the very greatest pages in the history of modern thought. Only the work of Copernicus, Bruno, and Galileo regarding the place of earth and sun in the universe can be compared to it. And the student must for ever rid himself of the popular error that a man called Darwin wrote an unheard-of book in 1859, which shocked nearly everybody, but which ultimately proved and explained "the Darwinian theory," that men are descended from monkeys.

Jean Baptiste Lamarck. The great forerunners whom we have mentioned were not naturalists themselves, for the most part. Kant and Bruno were philosophers, with a leaning towards astronomy. Erasmus Darwin was a doctor and Goethe was a poet. Buffon certainly was a naturalist, and a great one; but it needed a greater still to make a real beginning, broad-based and deep-delved, for the modern science of organic evolution. The needed man was forthcoming in the person of Jean Baptiste Lamarck, the master of masters in this subject. With him begins the science of organic evolution.

In Great Britain he has long been the butt of ignorant commentators who have never read his works, and, above all, of the so-called "neo-Darwinians," who traduce the name and fame of Darwin by teaching a preposterous set of doctrines which their master himself expressly and powerfully repudiated. Indeed, in order to repair the injustice done to Lamarck, we need to consult Darwin himself, whom they commonly represent as the great opponent of Lamarck and exposer of his absurdities.

Darwin on Lamarck. This is what Darwin, who loved Truth in so rare degree that he was never unfair to predecessor or contemporary, wrote of the Frenchman, whom he calls "this justly celebrated naturalist":

"He upholds the doctrine that all species, including man, are descended from other species. He first did the eminent service of arousing attention to the probability of all change in the organic as in the inorganic world being the result of law, and not of miraculous interposition. Lamarck seems to have been chiefly led to his conclusion on the gradual change of species by the difficulty of distinguishing species and varieties, by the almost perfect gradation of forms in certain groups, and by the analogy of domestic productions.

"With respect to the means of modification, he attributed something to the direct action of the physical conditions of life, something to the crossing of already existing forms, and much to use and disuse—that is, to the effects of habit. To this latter agency he seems to attribute all the beautiful adaptations in Nature, such as the long neck of the giraffe for browsing on the branches of trees. But he likewise believed in a law of progressive development; and as all the forms of life thus tend to progress, in order to accour for the existence at the present day of simp productions, he maintains that such forms now spontaneously generated."

Why Lamarck's Views Were Rejected. These views of Lamarck were first stated by him in 1802, but more especially in his great work, well named the "Philosophie Zoologique," which was published in 1809. The date is worth remembering, for it was that of Charles Darwin's birth, and is exactly half a century before the publication of Darwin's masterpiece, "The Origin of Species," in 1859. Another half-century, all but two years, takes us to 1907, which saw the publication of "Creative Evolution," by Henri Bergson, who was born in 1859, just as Darwin was born in the same year as Lamarck's masterpiece.

Now consider the state of the mental atmosphere at these dates, and at once we see why Lamarck had no chance, in his day, of finding the hearing which he deserved. In 1809, notwithstanding the isolated voices of perhaps one great man in Germany, another in England, and another in France, the voice of orthodoxy was overwhelming. Men of science were not even inclined to question the authenticity of Genesis.

The most authoritative and influential naturalist of the age was the Frenchman Cuvier, a famous student of fossils and of the skeletons of animals. Not for a moment would Cuvier listen to Lamarck's ideas. For him species were fixed; and if the remains of other than existing forms of life were found in geological deposits, they must have been destroyed by some convulsion of Nature, while later forms must have been specially created to people, later, the strata of the earth's crust.

The Gradual Recognition of Evolution. But knowledge moves on. The geologists were responsible for a great development. They showed, above all in the person of Sir Charles Lyell, that the history of the earth's crust had not been one of catastrophes, destroying all life, and succeeded by periods of no change, which new life inhabited. The "catastrophic" geology yielded to the "uniformitarian" theory, which declared that the earth's crust, and its strata, had been formed by the uniform action of slow but sure causes.

When this came to be accepted, a new theory of fossils was required. Meanwhile, further study of living beings was showing their relation to each other, and to man, in a fashion which could admit of only one interpretation. In the course of the decades onward from 1809, the mental atmosphere changed, so that, thirty or forty years later, "ideas of evolution were in the air," and soon began to find utterance on many sides.

We shall not understand the position of Lamarck unless we realise what changes thus occurred in the first half of the nineteenth century. Cuvier died in 1832, and in a few years Darwin was opening his notebooks for facts bearing on possible evolution of species, Tennyson was writing "In Memoriam," with its definitely evolutionary statements, and Chambers published anonymously his "Vestiges of Creation," which made an immense sensation.

The special theory of "natural selection," which we must later discuss, as Darwin's particular contribution to evolutionary theory, occurred independently also to Alfred Russel Wallace, who died in 1913, and to various other students of Nature before either of them.

Of these instances the most remarkable has only just come to light, being a book published by Sleeper, in Boston, somewhere in the eighteen-forties, and containing the "Darwinian theory" of natural selection, as well as an admirable statement of what is now so familiar as the germ-theory of disease.

The Champions of Lamarck. Contrast this with the state of thought into which Lamarck introduced his "Philosophie Zoologique." No wonder that not until Darwin wrote of him, half a century later, did his work receive anything like proper recognition; nor is there wonder even that only in the years now before us will Lamarck receive, outside of France and the United States, where his name has long been rightly honoured, the place which is his as the veritable founder of organic evolution. It needed very great, independent thinkers, concerned with Truth, irrespective of persons (including themselves), to appreciate this master mind.

We may do well to remember that Herbert Spencer consistently supported the views of Lamarck in this country, in a way which is only now beginning to be appreciated; that Darwin was always and explicitly a Lamarckian; and that, in Germany, the famous pioneer and champion of Darwin, Ernst Haeckel, who is still alive, said of Lamarck, that to him "will always belong the immortal glory of having for the first time worked out the theory of descent as an independent scientific theory of the first order, and as the philosophical foundation of the whole science of biology."

It is just possible that, in the illustrious company of Spencer, Darwin, and Haeckel, we shall be safer in honouring and learning from Lamarck than in the company of those who have never so much as read him. His name and his work are here offered to the reader, as of the highest, with the utmost confidence, as worthy of his most careful remembrance, notwithstanding the majority voice of secondhand biology in this country (and only in this country) today. If ever the student of scientific thought may venture on prophecy, he may do so here, and say that the name of Lamarck will steadily gain in honour, and his work in followers, during the decades immediately before us. To him, and to him first, we owe the statement of theories which such great evolutionists as we have named, half a century later, thought to be at the root of the matter; and when these theories are corrected and amplified by the deepest knowledge of today, as Bergson and Driesch are now doing, they are found, more than a century later, to illustrate in perfection "the survival of the fittest."

Criticism of Lamarck. It was just this idea of what Darwin called, rather unfortunately, "natural selection," and what Spencer interpreted as "survival of the fittest"—a term at once adopted by Darwin—it was just this that Lamarck missed. Today, the makers of what will be the biology of tomorrow know very well that this "natural selection," as we shall see,

was something of a mare's nest. But the conventional thing to say, in this country—and it is said by the historians of evolution, popularisers of science against religion, and so forth, continually—is that the idea of evolution, advanced by Lamarck and the rest, could never be accepted until Darwin provided the great idea *which explained* how evolution had occurred. Till then, it would have been wrong to accept evolution, there being no explanation of it. This was Huxley's view, and he, far more than all other men put together, notably including Darwin, was responsible for the idea that the theory of natural selection made all the difference between evolution as a speculation and evolution as a proven "law of Nature." Later we shall see how much or how little "natural selection" accounts for, using the knowledge and the thought and the new experiments of contemporary masters, such as Bergson, Driesch, and Bateson, each in his own distinctive field.

Science Establishes the Theory of Evolution. Meanwhile, the student will gather from the brief historical sketch which this chapter contains that the real reason why evolution came to be accepted in the second half of the nineteenth century, instead of the first, was that science was moving on all the time, and that what was the daring idea of one or two men of genius at the dawn of the century was the only thing which any reasonable and unprejudiced person could believe half a century later. Beyond question, it was the great work of Darwin that made the triumph of evolution so rapid, when it appeared, and his services to Truth will be remembered as long as man endures; but it is merely insular vanity to suppose that the riddle of life was a mystery until Darwin said "natural selection," and answered it once and for all.

Lamarck believed that life, with its needs and functions, comes first, and structure second. What we may almost call the sub-conscious will of living beings is at the root of the wonderful structures which they display.

Lamarck's Ideas Illustrated. The most familiar illustrations of Lamarck's ideas are furnished by the neck of the giraffe, which embodies the wish and the need of the animal to reach the leaves of trees—a wish the results of which accumulate, he declared, from generation to generation; the long tongue of the ant-eater, the result of habit and use and will, in relation to the animal's diet; the half-erect attitude of the apes, leading on to the erect attitude of man—the result of Life's *trying* to get its head up, and amplify its horizon. Similarly Lamarck accounted for the structure of modern snakes, which he regarded—rightly, as we now know—as the descendants of four-limbed reptiles, by saying that, "having taken up the habit of moving along the earth and concealing themselves among bushes, their bodies, owing to repeated efforts to elongate themselves and to pass through the narrow spaces, have acquired a considerable length out of all proportion to their width. Since long feet would have been very useless, and short feet would have been incapable of moving their bodies, there resulted a cessation and use of these parts, which has finally caused them totally to disappear, although they were originally part of the plan of organisation in these animals."

The Neo-Darwinian School. Until the last few years, it has been the fashion in this country to laugh at these ideas—which were good enough for Darwin and Spencer and Haeckel, to name none besides—and to say that they were merely fanciful speculations which had been disproved and, in any case, rendered superfluous by the theory of natural selection. The school which is responsible for this attitude is known as the "Neo-Darwinians," and their theory is known as "Neo-Darwinism." Its influence was entirely dominant in Great Britain until the last five or six years, and unfortunately it held sway so long that it succeeded in establishing itself in the minds of most amateur followers of biology. Here it will be well for us to remember that Darwin expressly accepted, and utilised in his exposition of organic evolution, the theory which "Neo-Darwinism" rejects with scorn—that the results of habit, use, will, exercise, in the parent may affect the offspring. To use the name of Darwin as the chief prop of an argument which he rejected is not fair to that broad and fair minded man, and it is misleading.

The Theory of "Pangenesis" Rejected. The "Neo-Darwinians" had an argument for their name in that they rejected the theory of "pangenesis," which Darwin elaborated as a possible explanation of what he, like Lamarck, believed to happen. The word "all-begetting" means that all the body of the parent contributes to the offspring. The theory was that each part—say, the big biceps muscle of the blacksmith—must contribute a kind of representative or miniature replica of itself to the germ-cells. Darwin thought that the biceps, for instance, passed what he called "gemmules" into the blood, by which they were carried to the reproductive organs; and, of course, if the biceps were much developed by exercise, it might be expected to send more gemmules, or stronger gemmules, than otherwise. A kind of "proportional representation" of the various parts of the body, according to their development or non-development, could thus be conceived.

But this theory of the origin of the germ-cells, and their relation to the rest of the body, is now known to be incorrect, and "pangenesis" has long been abandoned in the light of the newer knowledge which we owe especially to Weismann. The Neo-Darwinians thus argued that, Darwin's theory being disproved, and no other being conceivable (by them, they should have added, but forgot), Lamarck's theory of the influence of parental habit and function upon offspring must be false. But soon we shall see how the Lamarckian doctrine may be, and has been, restated, in still profounder form than in 1809, by Bergson, writing in the same city of Paris just a century later.

C. W. SALEEBY

The Meaning of Salesmanship. The Duties of a Sales Manager. Efficiency Applied to Selling. Engaging and Controlling Travellers.

THE ORGANISATION OF SALES

When the manufacturing department of a business has turned out the articles for the production of which it exists, and they are sent away to the finished goods store, the first part of the work of the business is completed, but only the first part. The goods may be all that they should be, the materials used may be of the best, and the methods of manufacture may be perfect. But before they begin to turn over capital and earn profits for the business they have got to be disposed of, and for this there must be an efficient selling organisation.

In the old days of hand-made goods, when production was slow, there was probably little difficulty in selling all that could be made, for supply often found it hard to keep up with demand. In fact, it was this difficulty that set clever men thinking, and led to the invention of machinery for making things more quickly. The spinning-jenny, the mule, the Bessemer method of making steel, and a thousand and one other machines and processes all came into being in this way.

But nowadays, when machinery moves more quickly than the eye can follow, when a thousand articles can be made in the time that used to be occupied in turning out a single one, when production is faster and ever faster, the disposal of the rapidly accumulating stocks is a problem that needs the very keenest brains for its solution. The old-fashioned methods of selling are as useless in the disposal of goods as are the old hand processes in their production.

Salesmanship a New Word. Salesmanship is practically a new word in the English language. Scarcely a dictionary, large or small, gives it, and yet it may be said to represent the very latest science, for selling has now been organised on scientific lines, and some of the best brains in all civilised lands are engaged in this profession.

Creating a Demand. The old idea was that the law of supply and demand was an absolute one, over which we had no control; that, in some way or other, there would be a certain definite demand for a certain article, and that if only that demand could be supplied, then all the business that was possible along a certain line would have been done. The sales manager of today laughs at any such antiquated idea. He does not deny that there is a law of supply and demand, that goods can only be disposed of when there is a demand for them, but he goes farther back, and says: "I must create a demand where none exists, in order to be able to supply that demand; or if there is a demand already existing, then I will double and treble it, so as to be able to do more business." Then, in order to carry out the determination which he has made, he concentrates all his attention and powers, and unites to them the work of other brains than his own, and builds up a great organisation, ingenious in its intricacy, daring in its boldness, elastic in its adaptability, and unromantic in its name, for it is called by the very prosaic title of the "selling department."

Importance of the Selling Department. It is, however, the very life of every great business, and whether it be in the selling of ironclads or pins, of jewellery or jams, of machinery or doormats, the principles involved are the same. All the time the sales manager and his staff must be looking out for new markets at home and abroad, and must, at the same time, be trying to extend the old ones. Customers already on the books must not be allowed to slip away, and there must be a firm determination on the part of all to increase the number of customers and the amount of the turnover regularly and systematically. Only by setting such an ideal before itself can a selling department keep up to the standard of efficiency which it must attain to if it is going to be of the fullest service to the business of which it is a part.

Formerly it used to be said that if a man did not drink he could never make a good salesman, but nowadays a far saner view is taken of things, and probably more than 50 per cent. of the most successful salesmen are abstainers. Only a keen-witted, live man who keeps himself up to date in the knowledge of the time, and physically fit, can hope to hold his own in the particularly difficult and strenuous field of salesmanship.

Salesmen as Public Benefactors. We often speak admiringly of the men who have done much for the world—the scientists, the philanthropists, the statesmen, the engineers, the explorers, and so on, but, after all, it may almost be said that we owe more to the salesman than to the distinguished men who have been referred to; for, no matter what the scientist may have discovered, or the engineer have built, or the explorer have found in unknown regions of the world, none of these benefits would ever have been made available for mankind at large were it not for the salesman.

Instances of Salesmanship. A writer on this subject has said very truly of salesmen that they "have done more for progress and civilisation than anyone imagines . . . They have transformed the 'man with the hoe' into the man with the self-binder. They have given us the radiator for the fireplace, the piano for the dulcimer, the automobile for the push-cart, the typewriter for the quill pen. They have put more comforts into the cottage than the king used to have in his palace." He goes

on to show that the demand as well as the goods has to be manufactured. "There was no demand for the railroad," he says, "and for years many people believed that thirty miles an hour would stop the circulation of the blood. There was no demand for the steamboat, and when Brunel drove the first boat by steam on the Thames he became so unpopular that the London hotels refused to give him a room. There was no demand for the sewing-machine, and the first machine that Howe put on exhibition was smashed to pieces by a Boston mob. There was no demand for the telegraph, and Morse had to plead and beg before ten Congresses before he received any attention. There was no demand for the air-brake, and Westinghouse was called a fool by every railroad expert because he asserted that he could stop a train with wind. There was no demand for gaslight, and all the candle-burners sneered at Murdock for trying to have a lamp without a wick. There was no demand for the reaper, and McCormick preached his gospel of efficient harvesting for fourteen years before he sold his first hundred machines.

"No; it is not true, as learned theorists have said, that every great invention springs into life because it is demanded by the nation. It springs into life, and nobody wants it. It is the Ugly Duckling. Everybody prefers ten cents to it, till a few salesmen take it in hand, and explain it."

The Genius of Salesmanship. How many an inventor has died poor with his invention unknown, simply because he was so unfortunate as not to have the services of an efficient salesman at his disposal! We think of the inventor or discoverer as a genius who has conceived some new idea, but we must not forget that the true salesman is just as much a genius, for while the inventor can often interest only a select few who have a knowledge of science, the salesman interests the multitude for its own benefit, for the inventor's benefit, and incidentally also for his, the salesman's, benefit. No invention, however good, and no manufacture, however wonderful, can be of any use to the public, or can be of any profit to its promoters, unless there is real, live selling force behind it.

What Good Salesmanship is. It is obvious, then, that salesmanship is something more than the mere offering of goods for sale in a shop or warehouse. "Good salesmanship," someone has said, "consists not in selling what a customer must have, what he is forced by necessity to get, what he must have gone after himself if it had not been brought to him. It consists in selling him what he did not intend to buy, and this is done by good display, by bringing the goods rightly to his notice so that he notes qualities he did not know they possessed."

The Three Essentials. Three things are absolutely essential to successful salesmanship: Firstly, organisation; secondly, efficiency; thirdly, co-operation. Nowhere is organisation more necessary or more complex than in the selling department. At the head must be a capable sales manager, with a wide experience of the trade, a profound knowledge of humanity, a gift for inspiring his subordinates with loyalty and enthusiasm, and a living faith in his own proposition.

The Sales Manager's Duties. He will either have a publicity department under his control, or will work in close co-operation with the advertising department; for, as has already been explained, and cannot be emphasised too much, every selling scheme is an advertising scheme, and every advertising scheme is a selling scheme. He must have a statistical department, where, by means of the card index, the results of every scheme that is organised can be recorded and made traceable at a moment's notice; he must have an adequate staff of travellers, each with his properly defined territory, and must be in close touch with these all the time—men who have faith in him, and in whom he has faith. The sales manager's staff at headquarters, too, must be adequate and competent, for there will be schemes to follow up closely, lagging customers to be spurred on, correspondence to handle promptly, and a thousand other details to be attended to. Without organisation of the most careful and scientific kind there can be no selling department in the up-to-date sense of the term.

The Need for Efficiency. Then there must be efficiency in every branch of the work. Efficiency is a word that has a regular dictionary meaning, "productive of effect, competent, capable." But in business it is, like salesmanship, a new word, and not only a new word, but a new idea. It cannot, like the dictionary meaning, be defined in a short sentence. It is the placing of a business organisation or department on a scientific basis, so that the maximum of result with the maximum of quality may be produced at the minimum of expense. Apply the principles of efficiency to the engine-room, and less coal or gas is burned, more energy is produced, and there is less wear and tear of the fabric of the machine. Apply efficiency to building operations, as has been done in America, and is now being done here, and the movements necessary in laying bricks are reduced by over 70 per cent., the output of each man increases correspondingly, and the cost of building is reduced in a way that a few years ago would have been regarded as impossible.

Efficiency Applied to Selling. Efficiency applied to the selling department has just as remarkable results. The travellers, or salesmen, as they are now more generally called by up-to-date business houses, used to be given a sort of roving commission, and sent out to sell the goods of their firm as best they could. Each man told the story that he thought most likely to effect sales. He worked more or less independently of headquarters, and provided he sent in a reasonable number of orders, and these orders showed a moderate increase from year to year, nothing was said, and the man gradually became stereotyped in his methods. He nursed his old favourite customers, and did little in the way of looking out for new business. All that has been changed.

Selling Points. In the first place, the travellers must be told all the "selling points"

of the goods they carry and the firm they represent. These points are not thought out in five minutes by one man. They are the result of the collective wisdom and experience of all the travellers, the sales manager, and his staff, with the help and co-operation of the manufacturing department, the buying department, and so on. The buyer can give valuable points about the quality of the materials used in the manufacture: that they are of the best quality, that they are pure, that they are specially prepared, that they come from the firm's own mines, or quarries, or plantations, according to the character of the business and the goods manufactured. Then the manufacturing departments can give much useful information about the way in which the goods are produced: amid hygienic conditions, by specially trained workers, with scrupulous cleanliness, and so on.

Building up the Story. With these points as a basis, a clever sales manager can build up a complete story, embodying all the reasons why the buyer should give an order. The prospective customer's point of view must be carefully considered, for salesmanship has been defined as "making the other fellow feel as you do about what you have to sell."

Then the travellers must be encouraged to send in full particulars of all the complaints and objections with which they meet. To each of these there must be some "best answer," and every objection should be carefully considered by the sales manager and the best answers to all possible objections discovered and tabulated. All this information, constituting the story of the goods, should be typed out or printed, and copies given to all the salesmen, not with a view to their using stereotyped phrases, but as a basis upon which each can build up his own story, adapted to the peculiar people and needs of his own territory. It is astonishing how many travellers there are who go around trying to sell goods, and, when questioned, show that they know very little about their firm, and practically nothing about the conditions in which the goods are produced. No man can be a true salesman who does not know his goods thoroughly, and it is the duty of the sales manager to see that every man working under him and representing the firm outside has a good selling story. There must, however, be no misrepresentation to the travellers, the trade, or the public.

Importance of Truth. False descriptions of goods may result in temporary successes, but sooner or later the public and the trade will find out the truth, and then the sales will drop, and the sales manager will discover, too late, that he has lost the confidence not only of the trade and the public, but of his own men. Honesty in salesmanship is undoubtedly the best policy.

The Need for Enthusiasm. Then not only must the salesman have a story, he must be enthusiastic and inspired, and to make him this is the duty of the sales manager. He can do much by letter. There should be at least one letter a week going to every traveller from headquarters, and these letters should contain spur and incentive conveyed by means of an encouraging word, if possible, or, if that is impossible because the man has slackened, then by a suggestion that better things are expected of him next week. Such phrases as "You have done well this week," "We congratulate you on the result of this week's trading," "You will be glad to hear that Messrs. So-and-So have sent us a substantial order," "You have almost made a record this week," are oftentimes as great an incentive to a traveller as an increase in salary or a bonus cheque.

Inspiring Confidence. The sales manager should always convey the suggestion that he is taking the traveller into his confidence by telling him interesting items of news about headquarters. "We have begun our new offices," "We contemplate extending out factory premises," "Our new wing will be opened next month," and so on. He should also, of course, let travellers know beforehand of any special offer being made by post to his customers, or of any new line that is to be placed on the market. Nothing is more likely to kill the enthusiasm of a traveller than to find when he calls upon one of his customers that that customer knows more about the firm's business than he himself does.

Controlling Travellers. While doing everything of this kind to encourage and enthuse the travellers, the sales manager must at the same time keep a keen eye on them. He must see that they do not skim their territory, but work every part of it thoroughly; that no preferences are given to certain customers to the detriment of others; and that the men get the maximum of business from their ground. As will be explained when we come to deal with the statistical department, their work as recorded week by week must be most closely scanned.

Then their expense sheets must be examined and checked in relation to the ground covered and the business sent in, so that the cost of selling may be brought down to the lowest possible percentage. This is one of the great problems of salesmanship. It is of no use merely to cut down expenses arbitrarily. That is not good managership, for the result will be, sooner or later, to reduce returns. A man must be allowed adequate expenses for the work he does, and when he is well paid according to his results he will not be inclined to add to his income by scheduling fictitious expenses which go into his own pocket. It is very easy, however, for a salesman to get into the way of taking cabs when he might walk or ride in a tramcar or omnibus. On the other hand, it is false economy for a man to save eighteenpence on a cab and lose a fifty-pound order thereby. It is essential, therefore, that the sales manager should be a man who has himself travelled about the country a good deal, and knows the conditions of getting from place to place. He will, of course, visit his men on their own grounds from time to time, so as to study the peculiarity of each man's territory.

Checking Expenses in Detail. It is in order to check expenses that the old-fashioned system of letting a man lump all his expenses

together and then render a monthly or weekly account, for which he receives a cheque, has been abolished. In its place many houses insist upon a daily report from each salesman, with a more or less detailed account of expenses, and this has been found not only an effective way of keeping down costs, but an equally effective method of forcing up sales. No man likes to send in a sheet showing expenses on one side with little in the way of orders to balance them on the other side, and, in order that his daily report may not appear too one-sided or bare, many a man will put on an extra spurt and thereby secure an order that would otherwise have escaped him and perhaps have gone to a competitor.

Travellers' Conferences. The travellers must be brought together from time to time in conference, for, good as letters may be as a regular means of communication, there is something inspiring about a gathering where men meet face to face and exchange confidences. Of course, a travellers' conference may be a farce or an exceedingly valuable preparation and impetus to increased business. There, again, proper organisation comes in, and there should be a definite agenda and programme. Some of the large American companies working in England call their London men together every week for an exchange of notes.

Demonstrations of Selling. At a travellers' conference demonstrations of selling are given by the most competent men for the instruction of the younger salesmen, and discussions are encouraged. The men must be taught to use their voices without being frightened at the sound, and a spirit of comradeship and brotherliness must be fostered in order that there may be mutual helpfulness. Twenty or thirty years ago travellers would have laughed at the idea of coming together in conference and giving one another hints on salesmanship. "Why should I tell So-and-So how I do my work? Not likely!" That would have been the spirit then, but such motives do not animate a live staff of salesmen today. Rather it is "I must help the other fellow in order that he may help me."

A useful form of demonstration is to put up a clever salesman and against him another who represents a difficult customer. Then, while the latter raises every objection he can to buying the goods, the first salesman meets him at all points and answers his objections. An actual demonstration of salesmanship in this way does more to instruct younger men than volumes of reading and hours of lectures.

Encouraging the Salesmen. The men should be encouraged to tell how they obtained their biggest orders, how they cover their territory, how they approach their customers, how they carry their goods, and so on. And at these conferences full minutes should be taken, and later on the cream extracted and manifolded or printed, a copy being sent to each man.

Where the men are scattered all over the country, they cannot, of course, be brought together very often; but once a year, at any rate, they should all meet. At these conferences the sales manager has a splendid opportunity of inspiring his men. He should impress upon them that they represent the house in their territory, and its reputation stands or falls by their representation. No man should be allowed to think meanly of himself or he will make others think meanly of his house.

The Philosophy of Business. There is a great deal of sound business philosophy that is very obvious when a man hears it, but, strangely enough, until he hears it from another, he never thinks of it. Few men really philosophise about business, with the result that they never get the best out of themselves or their proposition. The sales manager must be a philosopher, and the knowledge he has he will impart to his men in such a way that they will be helped by it.

Engaging Salesmen. In engaging salesmen the sales manager will, of course, take men whose appearance at first glance prepossesses him in their favour. The man with a miserable expression may be a good fellow and he may make an excellent journalist or a conscientious civil servant, but he will certainly not make a successful salesman. So many people are guided by their first impression of men that it is absolutely essential for a salesman to have a prepossessing appearance and manner. The smiling face sells as many goods as, if not more than, the logical argument.

Analysing Returns. When the salesman's returns are analysed, it may be found that some men are down on the year's trading, or that they have made no progress. This does not necessarily mean that they are not good men, although, of course, the analysis makes it imperative that there should be a close scrutiny of their work. It is often the case, however, that a man who is a failure on one territory is highly successful on another. The man, for instance, who can work the West End of London well would probably be a failure in Lancashire; and certainly the successful Lancashire salesman is likely to have great difficulty in making good in the West End of London. All the circumstances, therefore, must be taken into consideration when going through the analysis of the men's returns. If the population in a district is principally engaged in a certain industry, and that industry is for some reason working half-time, then the people have much less to spend, and trade cannot possibly be as good as it is in normal times. Strikes, lock-outs, depressions in staple industries, all influence business adversely, and such considerations must not be overlooked when criticising a salesman's returns.

The Necessity for a Good Lead. Of course, the salesmen must be given a good lead, and every selling department will plan out selling campaigns from time to time. It is not enough to have the goods manufactured and the travellers out offering them for sale. The demand must be made just as surely as the goods themselves are made, and, though the travellers will be steadily at work all the year round, the selling campaign must be used as a stimulant to the men, the trade, and the public.

The Organisation of a Selling Campaign. It is essential that a selling campaign be very carefully organised. Everything must be thought of. The salesmen must be given full information of what is intended, and a high objective must be set before them. The trade must be properly approached both by the men and by correspondence, and the public must be moved by advertising. At the same time as the trade is being worked the consumer must be urged to buy by the publicity department.

Selecting the Time. First of all, the time selected for a special offer must be well chosen. It would be useless arranging a great scheme for the sale of straw hats in December, and an offer of heavy overcoats would fall just as flat in July.

Working out Details. Having settled the time for a special offer, the next thing is to work out details of the scheme. A special offer needs some special inducement to the trade, and what this is to be, whether a reduction in price, an exclusive offer to one shop in a town, or a stocking bonus, must be decided upon and set forth in a letter as briefly and tellingly as possible. The wording and get-up of such a circular is a very important matter, for just as the first impression created by a salesman may be favourable or unfavourable, and either assist or prejudice business, so a circular will be well or ill received according to whether it is attractive or unattractive at first glance and whether the opening sentences make a winning appeal.

The Follow-up. This being settled, the follow-up must be planned, for no up-to-date firm, in arranging a selling scheme, would be content to send out just a single announcement. From time to time during the period the scheme is in operation, that part of the trade that has not yet responded must be written to, and here, again, too much care and thought cannot be expended upon the wording and appearance of the follow-up letters. There must be a progressive character about the series, whether it consist of two, three, or more letters, and the appeal must get stronger and stronger as the time gets shorter and shorter. When the period of the offer is getting near its close, this can be used as an inducement to the traders to come in before they lose their chance.

Using the Trade Organs. The trade papers can be used for driving home the letters and circulars. The tradesman who receives a letter may put it aside and forget it, but he will remember it directly he sees an announcement in his trade organ. And here comes in the importance of having all the literature and letters dealing with the scheme co-ordinated in some way, so that the man who sees the first circular or letter and then receives the second, and also the announcement in the trade paper, may unconsciously connect these up in his mind. There will in this way be a cumulative effect about the various methods of approach that will have a great pulling power.

Advertising and Sales. If the article being sold is some household commodity, then the public must be moved simultaneously so that they may ask at the shops. This will act as a great incentive to the retailer, and if the advertising that is being done is at all extensive, then it is worth while setting forth particulars in the circular to the trade, for naturally the retailer will be far more prepared to stock a well-advertised article than one which is receiving no particular publicity. All this information, with copies of circular letters and advertisements, will be sent to the travellers in advance, so that they may be fully posted as to what is going on.

In the publicity work the sales manager will, of course, work in collaboration with the advertising department, whose work and methods are set forth fully in another part of this book.

Estimating the Demand. It may be said that it is very difficult to gauge the possible demand of the public for any particular line of goods. Half a century ago it would have been regarded as ridiculous to suggest that a demand could be anticipated with any approach to accuracy. There are few businesses today, however, which, if they are planning a selling campaign, do not get some idea of the demand that is likely to arise.

Manifold Duties of Sales Managers. Although, of course, the sales manager's duty is primarily to sell the goods provided for him by the manufacturing department, yet, being so closely in contact with the trade and the public, his opinion should carry weight in deciding just how the goods shall be issued to the public; and if he is, as he should be, a strong man, he will get his way in insisting that the character of the package and wrapper and so on shall be such that it appeals to the public for whom it is intended. After all, it is the selling department and not the manufacturing which has to get rid of the goods, and therefore it is essential that the voice of the sales manager should have considerable weight in this matter.

Quite apart from the special selling campaign, the sales manager and his deputies will have a great deal of work to do in handling correspondence. Every letter, whether it be from a salesman or from a customer, needs careful and individual handling. It is wonderful what a lot can be done by suggestion. A small order properly used by a clever sales manager can very often be made a lever for obtaining an increased order, and that without asking directly, providing some reason can be offered why the order should be extended.

Tabulating Returns. Where a firm is doing a number of lines, the daily orders need very careful examination, and these must be tabulated so that it may be seen which lines are selling and which are not. The sales manager will, of course, take good care to spur on his salesmen to push those lines which are hanging fire, and here again he will do it rather by suggestion than by direct request. If only one particular line is going badly, then a reminder to the salesmen about this line can be put at the end of a general letter.

Handling Complaints. All complaints from customers about goods received must, of

course, be handled by the sales manager, and if there is any fault in manufacture or packing, then he should have the authority and power to take up the matter very strongely with the department at fault. If the general sales manager handles the export as well as the home trade—that is, if there is no special export manager on the staff—then, of course, the packing department will consult with him as to how goods are to be packed ready for shipment abroad. So many questions arise here that the sales manager will have to find out from his customers or from a salesman on the spot their requirements, and pass on the particulars to the packing department.

Dealing with Orders in Rotation. The execution of orders as they come in will, of course, be under the control of the sales manager, who will make out in some systematic way instructions for the packing and despatch departments. Duplicates of such instructions will be filed in the selling department, so that at a moment's notice any customer's order may be turned up and particulars found of the quantities sent, the date of despatch, the route used, and so on. The whole story of an order must be traceable right through from its receipt to the actual moment of despatch, and at every stage it must be known who is responsible.

Samples for Salesmen. Where samples of the goods to be sold can be carried, the sales manager must see that the travellers receive them early, and that they have proper bags or cases for carrying them on their rounds. There are very few people about today like the men in the parable who bought land and oxen without first seeing them, and many an order that would have been lost has been secured and an argument clinched by the sight of an attractive sample, suddenly displayed to emphasise what was being said at the moment.

If the goods offered are perishable, then fresh samples must be sent at given intervals, or when the travellers ask for renewals. Where the goods are too large and heavy to carry, as in the case of gas-engines and motor-cars, then the salesmen should be provided with photographs, or, if possible, coloured representations; and if the selling argument is some particular part of the machine, then there should be enlarged photographs and explanatory diagrams showing how these parts work and their advantage over rival machines that have not these improvements.

The World's Greatest Sale. The sales manager must be constantly emphasising and impressing upon his staff the dignity of the business in which he and they are engaged. He must show them that salesmanship has now become one of the professions, and that though the word is new and even the idea as now practised, yet salesmanship has always existed in the world, and has been made use of by the greatest men in the greatest enterprises. For instance, it has been said that "when Christopher Columbus, after fourteen years of fruitless effort, stood in the Court of Spain and convinced Queen Isabella that she should furnish him with ships and men to sail in an attempt to discover the western route to the East, he had consummated the greatest sale in the history of the world up to that time. He had made Queen Isabella feel as he did about the great idea which he had for sale. The hard problem with him was to get means for making the voyage. Any first-class mariner could sail a ship as well as Columbus could, and there were doubtless many men in the world who could have taken the ships across the ocean as well as Columbus did, but there was no one else who believed in the idea strongly enough to sell it to any one of a small list of prospective Royal purchasers." The very earnestness and enthusiasm with which Columbus pursued his ideal should characterise every salesman who believes in his own proposal.

Circulars and Form Letters. The sales department will do a good deal of circularising, and should certainly have facilities for producing quantities of nicely typed form letters. These letters must have in them as much individuality as if they were actual individual letters. There must be selling power in each one, and it goes without saying that the tone must be earnest though bright, serious without being depressing. No letter should be long. The huge mistake that so many firms make is to send out long letters of two or three pages, which no busy man can possibly find time to read.

Avoiding Bad Debts. There is one point in connection with salesmanship that must be borne in mind, and that is the importance of avoiding, as far as possible, bad debts. Of course, a certain number of honest men fail every year through sheer misfortune arising from unforeseen circumstances, but good salesmanship seeks to eliminate bad debts. This can only be done by exercising care in opening new accounts and obtaining references where necessary, or making confidential inquiries with regard to the status of a prospective customer. Long-standing book-debts should never be allowed. Directly a debt is overdue the customer should be given clearly to understand that the account must be settled at once. This is, of course, a matter for the accounts department, but it undoubtedly concerns the selling department, seeing that the placing of a new name on the books is the work of that department.

Co-operation the Secret of Success. It will be seen, from what has been said, that co-operation is the keynote of success in salesmanship. The buying department co-operates with the manufacturing department in keeping down the cost of goods; the manufacturing department co-operates with the selling department in producing goods of the right kind and quality; the sales manager co-operates with his staff in organising a selling system and a periodical campaign; and the travellers co-operate with headquarters in placing the goods all over the country. Let one link of the chain fail, and the whole system goes, but, given that every link be a strong one, the chain holds and does its work in pulling in business that will mean prosperity and growth and wealth to the firm.

CHARLES RAY

Theories Regarding Light. Colour. Light Waves. The Speed of Light. The Ethereal Keyboard. Shadows. Intensity, Reflection, and Absorption of Light.

A STUDY OF LIGHT

The best fashion in which we can approach the gigantic subject of *light* will be by a brief historial retrospect of our knowledge. To this there needs only the preliminary statement which would establish the parallelism between light, sound, and heat in respect of the distinction that must obtain between the physical and psychological aspects of the subject. There is an objective reality corresponding to light—to what we call light. It is not in itself luminous, but ranges everywhere throughout the universe in utter darkness until it reaches a seeing eye. The blind man enters into sunlight; the light is there, but he cannot see it. If we were all blind, if the human race had happened never to develop the faculty of vision, we should not find it difficult to understand the objective similarity between waves of light, which we happen to be able to see, and the waves which constitute, for instance, the Röntgen rays, and which we are unable to see.

Theories of Light. It is with the great name of Newton that we may begin. In his day there were two rival theories of the nature of light—one known as the *corpuscular* theory, the other as the *wave* theory. The former is also known as the *emission* theory or *emanation* theory, and the latter as the *undulatory* or *vibratory* theory. It was generally accepted, and, of course, still is accepted and proved, that light consisted in the motion of something. This could no longer be doubted when the astronomer Römer, by making observations upon the moons of Jupiter, showed that light took time to travel from one place to another. When this fact was established, it became plain that men must seek for the nature of this something which moves.

The corpuscular theory of light held that the sensation of light is created by a stream of tiny particles which are sent outwards in straight lines from all luminous bodies, and which strike the eye. The wave theory declared that there is no motion of any substance through space, but only that special form of motion which we call wave motion. But this supposition necessitated the further supposition of a something in which the wave occurred—the something which may be called the *ether* or the *luminiferous*—that is to say, *light-bearing ether*. Various other branches of physics lent their support, by way of analogy, to one or other theory. The corpuscular theory was supported by already existing corpuscular theories of heat, electricity, and magnetism. (The reader of the course on chemistry will prick up his ears at hearing of this old corpuscular theory of electricity, for it will remind him of the corpuscles negatively electrified, of which he has there read.) The study of acoustics, on the other hand, lent considerable support to the wave theory of light. Acoustics was already in a comparatively advanced state. The very simple observation that a sounding body is found to vibrate when touched had early led men in the right direction. If sound, then, as no one could doubt, consisted of waves, why not light also?

The Battle of the Theories. Each theory had its supporters, while each certainly had its difficulties. The corpuscular theory of light seemed to be thoroughly compatible with the fact that light moves in straight lines. The geometry of straight lines and their relations corresponded admirably with the geometrical facts of light—its reflection and refraction. The fact of sharp shadows also seemed to favour the emission theory, and to militate against the wave theory.

The great mind of Newton had to choose between the rivals; but, primarily, Newton was not a mere theorist, but a great discoverer, and some of his discoveries in optics tell in favour of the one theory and some in favour of the other. It was in the year 1672 that Newton communicated to the Royal Society his great discovery of the compound nature of white light. As most people know, he darkened his room, cut a hole in the shutter, placed a prism in the path of a ray of sunlight entering, and so broke it up into its component parts. He says, "Light itself is a heterogeneous mixture of differently refrangible rays." Later, he replaced the hole by a slit—though it has been stated that he did not do so—and thus obtained a band of colours.

The Nature of Colour. We cannot do better than quote Newton's own words: "1. As the rays of light differ in degrees of refrangibility, so they also differ in their disposition to exhibit this or that particular colour. Colours are not qualifications of light, derived from refractions, or reflections of natural bodies (as 'tis generally believed), but original and connate properties, which in divers rays are divers. Some rays are disposed to exhibit a red colour and no other; some a yellow and no other; some a green and no other, and so of the rest. Nor are there only rays proper and particular to the more eminent colours, but even to all their intermediate gradations.

"2. To the same degree of refrangibility ever belongs the same colour, and to the same colour ever belongs the same degree of refrangibility. The least refrangible rays are all disposed to exhibit a red colour, and those rays which . . . . exhibit a red colour are all the least refrangible; so the most refrangible rays are all disposed to exhibit a deep violet colour, and . . . . those which . . . . exhibit such a violet colour are all the most refrangible."

In consequence of this pre-eminent discovery and others, Newton inclined towards the corpuscular theory, which we now know to be erroneous. The consequences for the advance of optics were lamentable. For the authority of Newton was so tremendous that the wave theory was delayed, one may say, almost for centuries before it recovered from his opposition. It is true that Newton recognised the objections to the corpuscular theory, but it is the characteristic of the followers of a great man not to see all round the subject as he does, but to jump at his main statement and ignore the qualifications.

The Wave Theory of Light. It was the great Huygens, a contemporary of Newton, who first paid to the wave theory of light the attention which was its due. Thereafter the theory was taken up by the mathematicians, though it never made any real headway until the magnificent work of Dr. Thomas Young, who was led to study light by means of his work upon the subject of the human voice for the purposes of a medical dissertation. This led him to study sound, and he records that he was overwhelmed by the analogy between certain of the phenomena of sound and those of colour. Thus he primarily attacked the subject not from the side of mathematics, but from that of experiment. He was led, however, to the works of the mathematicians who supported the wave theory, and came to the reluctant conclusion that Newton's objection to this theory—and especially the objection that no wave theory could explain the propagation of light in straight lines—could not really be sustained. Continuing to work at the subject, Young made the great discovery of the *interference* of light—a phenomenon which our previous reference to it under sound will make sufficiently intelligible for the present purpose. Young actually found how there are conditions in which the addition of light to light will cause darkness, and its removal will leave light.

Once the facts of interference were established it must surely have been impossible, we would think, for anyone to refuse to accept the wave theory, even though it necessitated the assumption of a luminiferous ether. Lord Brougham, alike ignorant and incompetent, made a celebrated attack upon Young in the "Edinburgh Review," so that, as Dr. Merz says, in his admirable account of the history of this subject, "The doctrine of the interference of light, the mainstay of the undulatory theory, was, like the atomic theory of Dalton, driven out of the country."

An Extraordinary Property of Light. The great labours of Young could not achieve real progress until his work was taken up by the Frenchman Fresnel, who dared to support Young in the very place (Paris) where the corpuscular theory had been so long maintained and apparently strengthened. Fresnel took up Young's experiments, beginning with the phenomena of interference and studying especially the coloured fringes that surround the shadows of small bodies placed in the way of a ray of light. He showed that the theory of wave motion, combined with the idea of interference, was not only compatible with the propagation of light in straight lines—which chiefly led Newton to reject the true theory—but actually explained such propagation. For Fresnel showed that all the sidewards-going waves, or almost all of them, interfered with each other, and so destroyed each other. And now a new difficulty arose. When a ray of light passes through certain crystals, such as Iceland spar, it is split up into two—a phenomenon which is called *double refraction*. Under these and other conditions, such even as simple refraction from any surface, light acquires an extraordinary property which Newton expressed by saying that it has *sides*. It will pass through a second obstacle if that be held at one angle, but not if the second object be then rotated through a right angle.

Polarised Light. Such light, by a very undesirable term, is said to be *polarised*. Now, this remarkable polarisation of light, to which we must, of course, return, would seem to be more or less explicable on the corpuscular theory, if we imagine the corpuscles to have particular shapes just as crystals have. It might be that they were all tilted in one direction or another, and thus could pass through some transparent body at one angle but not at another, just as a stout person may have to turn sideways to go through a turnstile. But the facts of polarisation could by no means be explained on any wave theory which asserted that light consists of waves of alternate condensation and rarefaction in the line of propagation, just as a wave of sound does. We cannot imagine the polarisation of a wave of sound or any similar wave. It cannot conceivably have sides.

Naturally, the discovery puzzled Young, and compelled him to admit that the balance of evidence almost seemed to turn against his wave theory. But Young was not to be beaten, and solved the difficulty in a similar fashion to that which Fresnel himself afterwards independently reached.

The Motion of the Waves. Young declared that if we assume the wave motion of light to be not to and fro in the direction of its motion, but to be *transverse*—that is to say, at right angles to its line of propagation—the facts of polarisation can be readily explained. The apparent *sidedness* of waves of light simply means that, under certain conditions, the transverse vibrations constituting light are deprived of their common character (which is to vibrate in all planes, up and down as much as from side to side), and are reduced to one plane. Let us imagine that this plane is up and down or vertical. We can readily understand that light, the vibrations of which have been reduced to this one plane, will be able to get through a transparent object only on certain conditions. To take an example, a man is mainly vertical, and can readily pass through a vertical door. Imagine the door rotated at right angles, the man will stick, the door will be opaque to him. But if we imagine the man multiplied by many men at all sorts of angles, it is evident that whatever the angle of the door, it will not be able totally to exclude him.

But to disprove the corpuscular theory of light, and to lay down the first foundations of the wave theory, was very far from completing the task. There remained, and still remains, indeed, the all but insuperable difficulty of comprehending the nature of the medium—the light-bearing ether—in which the waves of light are formed. To this subject, however, we need not return, as we dealt with it under Gravitation.

The Speed of Light. A brief discussion of the speed of light may legitimately be placed here, because the discovery that light has a speed at all was absolutely essential to the framing of the undulatory and emission theories alike. It used to be thought that light acted as we still believe gravitation to act—instantaneously. The fact that this is not so had to be discovered before any further advance in optics was possible. In 1676, the Danish astronomer Römer, working in Paris, calculated that light travels at the rate of over 186,000 miles per second [see page 907]. It is a fact of the utmost importance that, as we now know, the onward speed of light is *one and the same with the speed of other wave motions in the ether.*

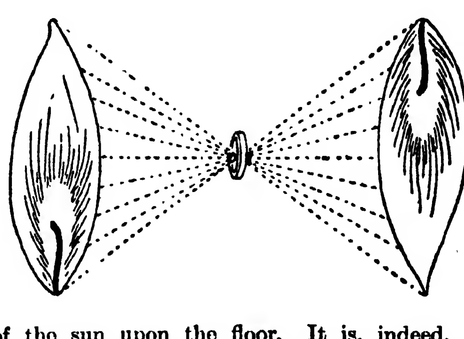
The Keyboard of the Ether. And here we must dispose of a difficulty which is involved not at all in the physical nature of light, but in the physiological constitution of our own bodies. In the case of sound we saw that the air, for instance, is able to vibrate to and fro at a very large number of different rates per unit of time, out of which we can, so to speak, merely cut a slice, and call it sound. So far as we are concerned, there are sounds which are too low in pitch for us to hear, and sounds which are too shrill. The same is true of light. This perfectly elastic substance, the ether, is able to display transverse vibrations of many, or, indeed, any frequencies per second. From this indefinite series of vibrations we, with our limited eyes, cut out a slice and call it light. In studying sound we saw that the upper octave of a note has a frequency exactly twice as great as that note. Now, the eye is able to perceive, as light, ethereal waves of a series which just corresponds to one octave. The sound we know has a limit of nine to eleven octaves, but the eye is able to perceive only one octave of light. Above and below this there are more ethereal vibrations, the existence of which we can demonstrate indirectly, but which do not affect the retina, and to which, in short, we are blind, just exactly as if we were able to hear one octave picked out from the middle of the piano and were stone deaf to all above and below it.

Its "High Notes." The compass or gamut of the ethereal keyboard is daily being extended. Our knowledge of it, at present, is in a curiously imperfect condition; the whole keyboard is there in nature, but we only know, so to speak, a few notes here and a note there. Somewhere in what, for convenience, we may call the middle of the keyboard we have discovered a complete octave—the octave of light. At its upper limit, also, we have more recently discovered a few notes more which, as the last note that we can see we term violet, are distinguished as ultra-violet light, or, more accurately, the ultra-violet rays. Then there is a great gap in the keyboard which we are trying to reconstruct, or, rather, for which we are groping. There is somewhat dubious evidence in favour of the view that a few notes of this gap have been discovered during the past few years. But if we grope on still further, passing a doubtless complete series of notes which are there, though we cannot discover them, we reach a few very *shrill* tones, so to speak, which are called the Röntgen rays, and which must later be discussed at length.

Its "Low Notes." Similarly, if we pass downward from the central octave of which our eyes assure us, we reach, directly continuous with the red rays—themselves endowed with no small heating power—a series of heat rays. These are of very great variety. The great American physicist the late Professor S. P. Langley devised an amazingly delicate apparatus for the study of these ethereal waves, which, if our eyes were somewhat differently constituted, we should doubtless be able to see. The *bolometer* of Langley—an instrument so delicate that it would be able to record, at the distance of a mile and a half, the heat radiated from a human face—enabled its inventor to demonstrate the existence of a long and complicated heat spectrum precisely comparable to the spectrum of visible light. But even below this many notes have been picked out from the ethereal keyboard.

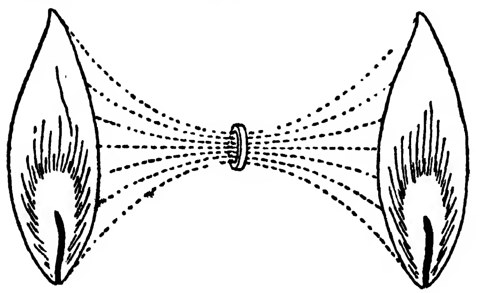
We must now pass to consider certain of the simplest facts of light, and, first, we may study that striking fact which is so characteristic of light, distinguishing it, apparently, from sound, and which Newton thought to be incompatible with the theory that light is a wave motion.

Light Moves in Straight Lines. If we repeat the classical experiment of Newton—at any rate, to the extent of piercing a hole in a shutter—we find that we obtain an image



of the sun upon the floor. It is, indeed, an image of the sun and not of the hole, because we may vary the shape of the hole as we please, but will still get the same result. Everyone must have noticed also how, on a moonlight night at the seaside, one may chance to see a perfect image of the moon in any little pool of water that may have been left among the rocks. All these circumstances tend to favour the view that light moves in straight lines.

The Inverted Candle. Or we may perform a simple experiment by making a pin-hole in a screen and placing this near a candle, the flame of which is at the same height as the pin-hole. We find that the image of the candle is thrown upon any surface that may be placed on the far side of the screen; but it is an inverted image, the candle flame is upside down. This simple and startling experiment has an extremely simple explanation. Any reader can draw for himself the flame and its inverted image, having them opposite one another and placing between them a point, through which the rays from every part of the flame have to pass. If the rays are to pass in straight lines the image must be upside down.



The second figure shows the curved course necessary if the image were not to be upside down. The same is true of the image of the sun in the case of our other experiments.

Pencils of Light. Strictly speaking, we cannot speak of a single ray of light, but must conceive of many rays forming a bundle or pencil. The rays in such a pencil may be moving in various directions relatively to one another, though, of course, each is rectilinear. When we refer to a very distant source of light, we may conceive of the rays forming a pencil as parallel. It is true, of course, that the rays filling the pupil of the eye never can be parallel, even when they come from the most distant star. Nevertheless, for all practical purposes, the rays transmitted, at any rate from a star, may be regarded as forming a parallel pencil, and indeed, for the ordinary purposes of eye testing, it is possible to regard as parallel the rays from objects that are not very many feet away. On the other hand, when a pencil of rays has passed through a lens the light forms divergent pencils. With a different shape of lens—such as each of us possesses in his own eye—the divergent pencil of rays may be converted into a convergent pencil [see illustration].

THE COURSE OF RAYS IN A PENCIL OF LIGHT

In this latter case it is, of course, evident that the rays must meet one another at a point, and this is known as the *focus*.

Kinds of Shadows. These simple distinctions enable us to understand the variations between different kinds of shadows. When a man makes "rabbits," and so on, with his hands in front of a magic lantern screen, sharp shadows are produced. The sharpness will be absolutely perfect under conditions which, perhaps, can scarcely ever be realised—that is to say, when the source of light is a luminous point and no more. In such a case, as light moves in straight lines, the placing of any object in the divergent pencil of light rays must necessarily produce an absolutely sharp shadow. There can be no complication. A certain number of rays are cut off by the obstruction and a certain number escape. But the moment the source of light becomes anything other than a point, then sharp shadows cannot be obtained.

The Intensity of Light. The reader will readily be able to guess that there is a simple law which determines the variations in the intensity of light with distance, and also the exact statement of that law. It needs only to remember the law of gravitation and the similar facts in the case of radiant heat and sound. The intensity of light varies at any point inversely as the square of the distance from the source of light. It can be shown that this must be so, whether the corpuscular theory or the wave theory of light be true. Various means have been adopted for estimating the intensity of light at any point. Such means are technically known as *photometers*.

Perhaps the oldest and simplest photometer is that invented by the celebrated and remarkable man Count Rumford. Rumford's photometer is simply, in its essence, a screen of white paper, in front of which is placed an upright stick, capable of casting a shadow. If two sources of light be placed beyond the stick, two shadows will be cast. The eye is then able to compare the depth of the two shadows, and it is found that when sources of light of various strength are used, the law of inverse squares is confirmed. This may be done by employing a standard source of light, such as the *standard candle*, which consumes 120 grains of spermaceti per hour. On the other hand, if we assume the truth of the law of inverse squares, the photometer enables us to value or appraise the illuminating power of any new source of light.

Bunsen's Device for Estimating Intensity of Light. Bunsen's method depends upon the fact that a grease-spot on a piece of paper looks lighter than the rest of the paper if we look through it at a source of light, but darker if the light and the eye be on the same side of it. Thus the intensity of light produced by two rival sources of illumination, one on each side, is equal when the grease-spot cannot be seen at all, and their value can be measured if their distances be compared. Very many photometers have been invented since these days, and those now used are very much more sensitive; but it would require considerable space to describe them properly, and they introduce no new principle.

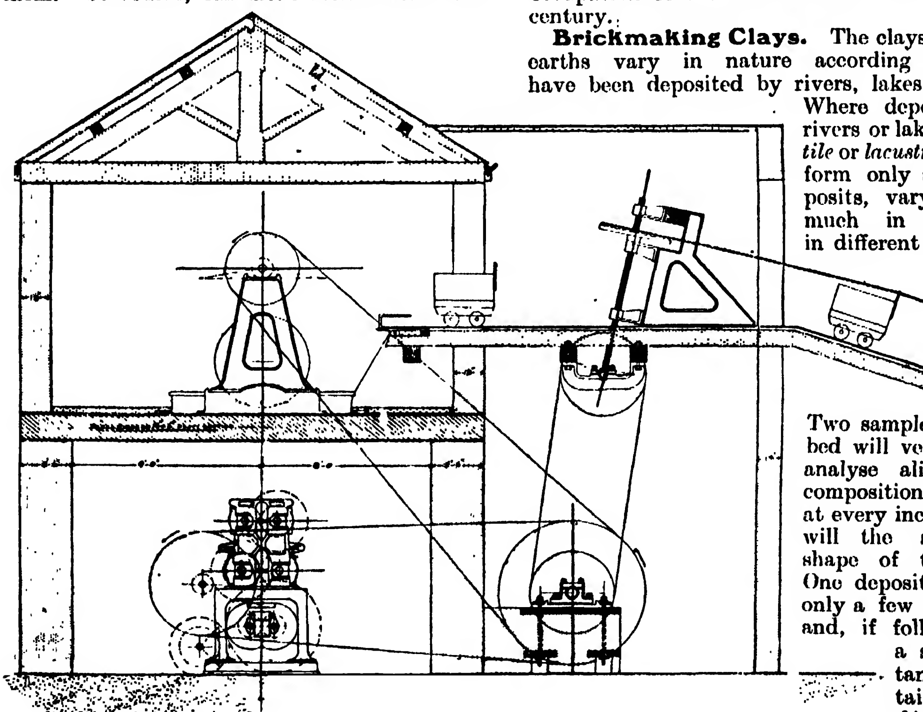
C. W. SALEEBY

Clays and Clay Deposits. Iron and Brick Colours. Brickmaking by Hand and Machine. Fire Clay and Fire Bricks.

BRICKMAKING

The origin of the art of brickmaking dates back to remote ages, and is, indeed, one of the very oldest of the crafts. Any plastic earth which can be moulded and sun-dried or baked may be made into a brick. In all probability the first bricks made were only sun dried, although among the earliest ruins of Egypt and Chaldæa may be found not only the sun-dried but also the properly burnt bricks. Herodotus tells us that the walls of Babylon were built of bricks made from clay dug from the trenches, and in Mesopotamia there are enormous mounds, all that remains of brick-built cities. If these bricks be examined it will be found that the outer layers are usually burnt bricks, while those on the inner side of the walls, where they would not be subject to the action of water, were made of sun-dried bricks. Many of these bricks were covered with stucco to protect them. Of course, sun-dried bricks were much more easily destroyed than those properly baked—indeed, we may read in ancient history that towns have been captured by invading armies who diverted a stream to run around the walls, which, being made of sun-dried bricks, were soon washed away. Although in Egypt most of the temples were built of granite or similar rocks, bricks were very much used for many of the buildings, and there still stand brick Pyramids, such as that of Sakkarah. The Biblical stories of the Children of Israel forced to make bricks are well known to all. These bricks seem to have been sun-dried bricks, and were moulded from material made by throwing cut straw, mud, and water into a pit and treading until sufficiently well " pugged."

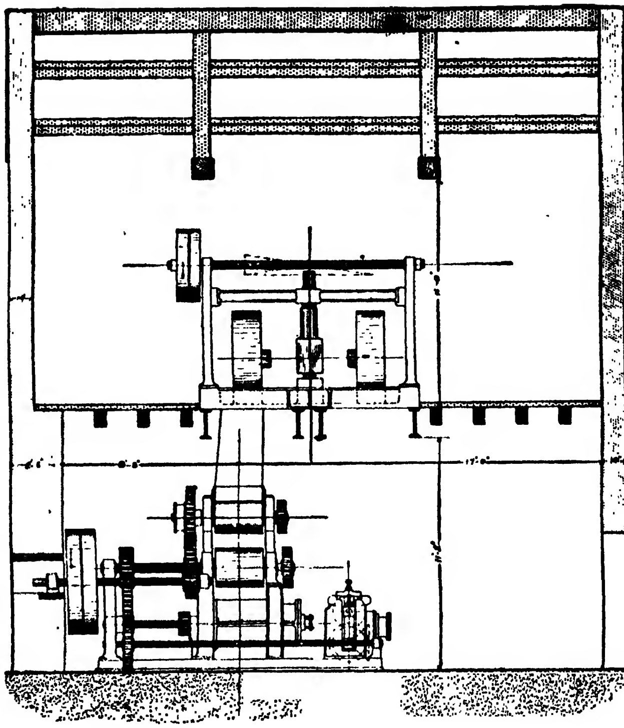
Another example of the use of a mixture of burnt and unburnt bricks is to be found in the Great Wall of China, and in Spain the sun-dried brick is often used at the present day. The Romans were probably the first to burn bricks in kilns, and the art seems to have been lost, at any rate in this country, as no trace of brick buildings is to be found between the time of the occupation of the Romans and the thirteenth century.



1. JOHNSON'S PLASTIC BRICKMAKING MACHINERY: LONGITUDINAL SECTION

Brickmaking Clays. The clays or brick earths vary in nature according as they have been deposited by rivers, lakes, or seas. Where deposited by rivers or lakes (*fluviatile* or *lacustrine*), they form only small deposits, varying very much in character in different localities. Take, for instance, brickfields in any part of Surrey or Kent. Two samples from a bed will very seldom analyse alike; the composition will vary at every inch, and so will the size and shape of the beds. One deposit may be only a few feet deep and, if followed for a short distance, will tail off and disappear; while another, which is scarcely noticeable, will broaden out into a deep bed. The Reading brick clay area is an example of lacustrine deposit. The marine deposits are notable for their great depths and uniformity, brought about by the uniform and regular action of the sea.

The big clay deposit in the Midlands known as the Oxford clay, and so much used for bricks in the neighbourhood of Peterborough, is a marine deposit. Analyses of the clay, taken at varying depths, all show much the same figures, and the extension of this deposit, which crops up again in France, scarcely varies from that dug in England. It will be readily understood that the marine clays are treated for brickmaking on quite different lines from the South of England clays, which are of fluviatile or lacustrine origin—*i.e.*, deposited by the agency of rivers or lakes. In the former case, powerful plant and big machinery are employed. The clay varies so little that it may be taken out for brickmaking with the certainty that, once having secured the right conditions, it will always give the same excellent results. On the other hand, in the South of England small hand machinery is better adapted to work the deposits, which have to be dug and carefully mixed, so as to get the desirable consistency.

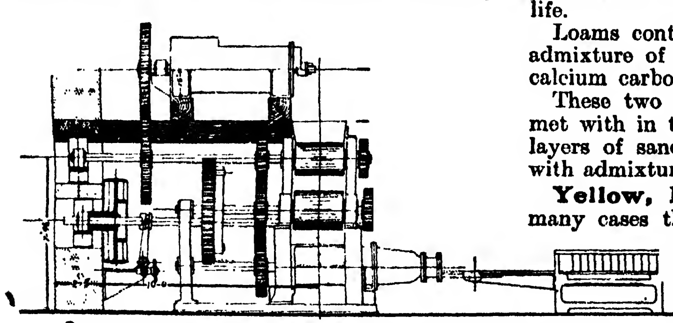


JOHNSON'S PLASTIC BRICKMAKING MACHINERY: TRANSVERSE SECTION

Classification of Clays. Clays can be roughly classified into plastic, or strong clays, loams, or mild clays, and marles, or calcareous clays.

In the first class, among the plastic, or strong clays, we may put the purer clays, although the purest of them all, kaolin, or china clay, is never so plastic as some of the others. The Oxford clay belongs to this type. It has, however, some disadvantages, as it contains much sulphur, in the form of iron pyrites.

In the course of burning the bricks, sulphurous fumes are given off in large quantity, and tend to bring about the formation of sulphuric acid. This has a tendency to *weather* out of the brick, causing the latter to go to pieces. The corrosive action of the sulphurous fumes is very noticeable in its effect on the chimney stacks which create the draught in the kilns. The acid attacks the mortar between the bricks, and in the Peterborough district the stacks are constantly under repair. We examined some bricks from within twenty feet of the top of a stack; they were intact, although the mortar was reduced to slime.



3. BRICKMAKING MACHINE FOR "WIRE-CUT" BRICKS

The strong class of clays are often improved by judicious admixture with other substances. Generally speaking, brickmaking clays are composed of other materials in addition to the silicate of alumina, or true clay substance. They contain oxides and phosphates of iron, and occasionally organic matter, iron pyrites, etc. The organic matter is the residue of the putrefaction of extinct vegetable and animal life.

Loams contain, besides the clay proper, an admixture of sand, while the marles contain calcium carbonate, or chalk.

These two latter clays are more commonly met with in the South of England, often thin layers of sand and clay occurring alternately with admixtures of the two.

Yellow, Red, and Blue Bricks. In many cases the colour of a brick affects the selling price more than anything else—especially where a brick is required for facing—with the result that colour often takes precedence to soundness.

Now, the whole range of colour in bricks is due almost entirely to iron, in some form or other. If a clay, consisting of more or less pure silicate of alumina, contains 1 per cent. or less of iron, the burnt brick will be white. As the proportion of iron increases,

the colour will pass from yellow to orange, and then to red. With 5 or 6 per cent. of oxide of iron, a good deep red will be obtained. With larger proportions of iron, the colour is still deeper.

The colour is also better developed by stronger firing. If the brick will stand it, and there be enough iron, the colour of the brick will pass from red to blue, and even to brown or black. The Staffordshire blue bricks, so much used for engineering work, are well-known examples of the case in point.

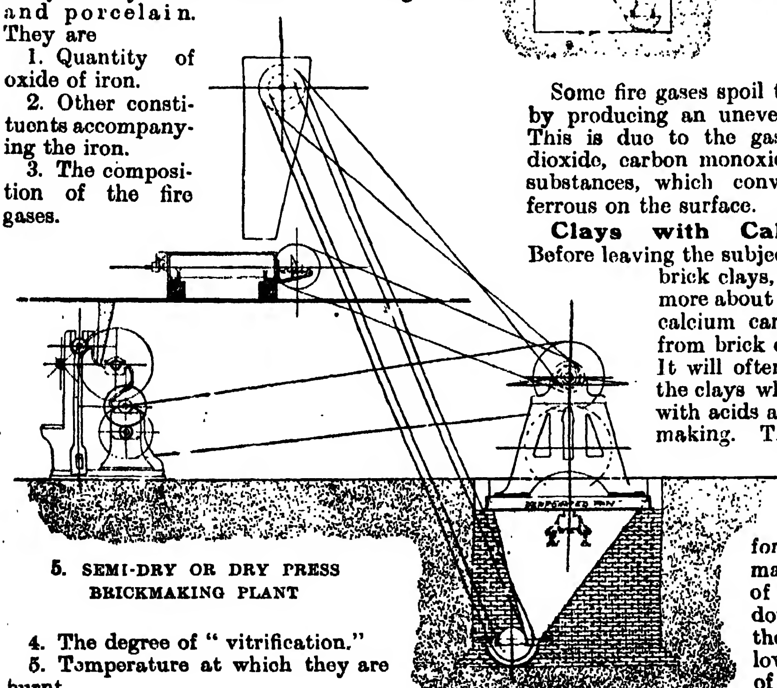
Manganese, a metal allied to iron, also affects the colour of the brick, producing a brown shade, but the proportion of manganese in the clay is so small that it can usually be left out of account.

Modification of Colour. The colour is also much modified by the presence of carbonates of lime and magnesia, and the condition in which the iron itself is present will also affect the colour, so that a knowledge of the percentage of iron in a sample of clay will not indicate accurately what colour the burnt brick will be.

A reference to the course on CHEMISTRY will show that iron, in the chemical sense, may be in either the ferrous, or the ferric state. It is in the latter form that it colours the brick.

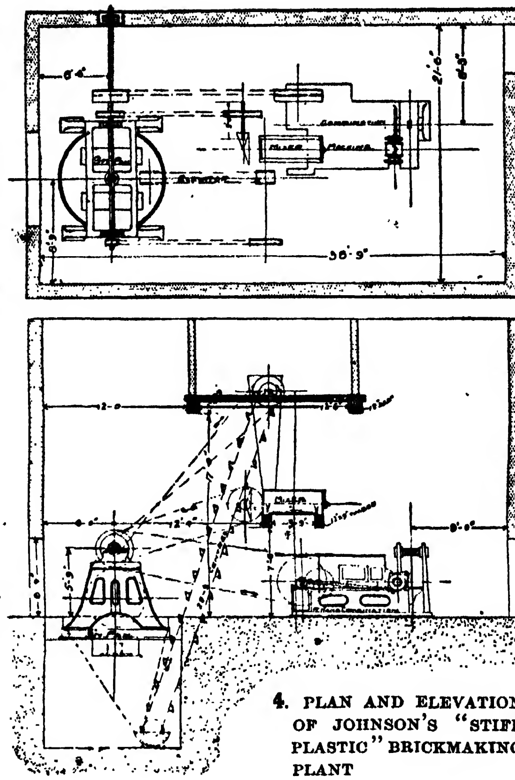
The most important factors which affect the colour of a brick have been summed up by the German chemist Seger, who made a life study of clays and their use in making bricks and porcelain. They are

1. Quantity of oxide of iron.
2. Other constituents accompanying the iron.
3. The composition of the fire gases.
4. The degree of "vitrification."
5. Temperature at which they are burnt.



5. SEMI-DRY OR DRY PRESS BRICKMAKING PLANT

The presence of carbonate of lime *bleaches* the colour of bricks, and they burn to a yellow tone, as, for instance, in the case of the well-known London *stocks*. Three per cent. of chalk will neutralise 1 per cent. of iron, and give a yellow instead of a red brick.



4. PLAN AND ELEVATION OF JOHNSON'S "STIFF PLASTIC" BRICKMAKING PLANT

Some fire gases spoil the colour of the brick, by producing an uneven, mottled appearance. This is due to the gases containing sulphur dioxide, carbon monoxide, and other reducing substances, which convert the ferric iron to ferrous on the surface.

Clays with Calcium Carbonate. Before leaving the subject of the composition of brick clays, we must say something more about the effect produced by calcium carbonate on bricks made from brick earths which contain it. It will often be found stated that the clays which effervesce strongly with acids are unsuitable for brickmaking. This is not always the case; at all events, if the calcium carbonate is finely divided and distributed uniformly througbout the mass. Lumps, or nodules, of limestone are undoubtedly harmful. As the calcium carbonate lowers the melting point of the clay, it promotes the slight amount of vitrification or fusion necessary in making a sound brick. Twenty-five per cent. of calcium carbonate may be allowed if the brick be well burnt. Such clays can be worked into a bar for hand brickmaking, with 20 to

24 per cent. of water reckoned on the weight of dry substance, whereas the strong clays, free from lime, require 25 to 30 per cent. of water. These points have to be taken into consideration when working the clay in the pug mill. In the process of burning, calcareous clays give off carbon dioxide, which modifies the structure or nature of the brick to a considerable extent, as the escaping gas leaves the brick full of tiny holes, and makes it more porous. In many cases, such a brick will stand the weather much better than a dense, smooth brick. Water which may permeate into the interstices will in cold weather do little harm when it expands on freezing [see PHYSICS], while with a close, hard brick there are still innumerable minute cracks and fissures which absorb water readily, so that when a frost comes the water freezes and rapidly disintegrates the brick.

Hand-made Bricks. This is carried on mostly in the South of England, and is suited to the small deposits of varying composition.

Clays are first dug and, if too strong, are mixed with the right proportion of sand or poorer clays by heaping them in layers one on the top of the other. When carted away to be worked up, the men are careful to dig through all the layers, and cart away the different ingredients in the right proportions. If the clay contain flints, chalk, or pieces of rock, it has to be washed. For this purpose, it was formerly the custom to dig a hole 3 ft. deep, termed a *wash back*, or *pan*. The clay was washed out of the mass into this pan, with sufficient water, and left to itself long enough to allow the clay to settle. The water was drained off, and the material dug out. Nowadays modern mills are provided with washing pans having the form of a circular trough. Revolving arms are fixed to a vertical staff in the middle of the trough, and carry harrows suspended by chains. When they are driven round, the harrows churn up the mass of water and clay, which is run off, leaving the deposit of stones, unbroken lumps, etc., on the bottom. The general principle, however, is exactly the same as in the old-fashioned pits. [See also CEMENT.]

6. SEMI-PLASTIC BRICKMAKING PRESS

Weathering and Tempering. Before the clay is mixed with water, or *tempered*, as it is termed, it is allowed to *weather*, by exposing it to the air. This weathering is of the utmost importance where hand-made bricks are manufactured, and where the machinery is not sufficiently powerful to break down lumps of hard rock into which water will not penetrate. Frosty weather is best suited for weathering, owing to the small quantities of water which permeate the crevices, expanding and splitting the stone when frozen. The weathered clay is carted to the pug mill, where it is mixed with the right quantity of water and ground to a uniform pasty mass, or *pugged*.

The old pug mills consisted of pits sunk into the ground in which the clay was stirred up by a revolving arm worked by a sleepy old horse. In a modern pug mill, the motive power is derived from an engine. The mill consists of a large pan in which revolves a vertical shaft, fitted with two horizontal knives. In the bottom of the pan is an opening for letting out the pugged clay, and there is a scraper at the bottom of the shaft for emptying.

When the clay is sufficiently pugged, it is ready for *moulding*. This used to be done in hand moulds of iron or wood, but modern machines have largely taken the place of such primitive plant [see 11]. However, owing to the cost of transporting bricks, and the fact that in the South of England small quantities of suitable clay crop up in numerous parts where the installation of expensive machinery would not pay, large quantities of crude, hand-made bricks are still produced.

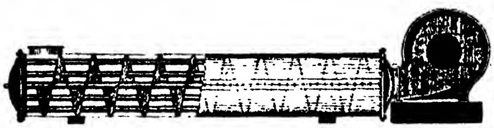
Wire-cut Bricks. In modern plants the clay is fed between powerful steel rollers, placed directly over the pug mill, which is often arranged horizontally.

The plant in the illustrations [1, 2, and 3] for working on this system is constructed by Messrs. Wm. Johnson & Sons, of Leeds. On the extreme right-hand side may be seen one of the trolleys in which the clay is brought up from the pit. It runs on rails which slope down to that part of the pit where the clay is being worked. When the trolley is full, it is drawn up by an endless chain, passing round a pulley, seen on the right-hand side of the drawing. The clay is tipped, generally by an automatic arrangement, into the pan, of a type of edge runner, termed a tempering pan. The pan is made to revolve by suitable cogs, and the clay is ground by the heavy rollers seen on the upper floor in 2, where the plant is shown in transverse section. The clay passes through small holes in the bottom of the pan, and is delivered to the rollers shown on the ground floor, which crush all stones, and the clay passes thence into the pug mill, where it is formed into a column or bar by the expression rollers. The bar is delivered on to a table, on which is a frame provided with a number of vertical steel wires, which can be moved horizontally by means of a lever. By this means the wires are driven through the bar of clay, cutting it up into separate bricks,

exactly as in a soap-cutting frame, or when a grocer cuts cheese with a wire. The cutting table is seen diagrammatically on the right-hand side of 3; on the left-hand side are the mixer and crushing rolls.

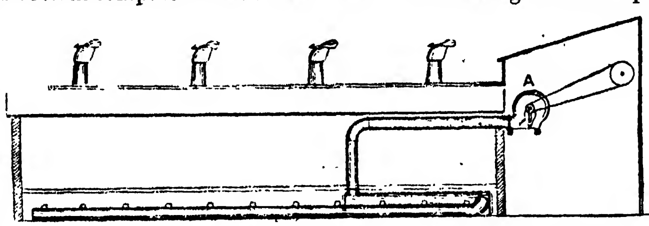
Another System. Another arrangement, due to Messrs. Whittaker & Co., Ltd., for the production of wire-cut bricks is worked on the following system.

The clay is delivered into the grinding mill. This consists of two heavy steel rollers resting on a pan, the bottom of which is made up in sections consisting of steel plates provided with small perforations up to ½ in. in diameter, and the whole pan revolves, being actuated by the cogwheel above. This plant is similar in construction to Messrs. Johnson's plant as shown in the figures.



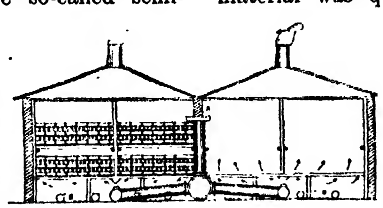
7. ROBINSON'S AIR-HEATER AND FAN

The clay is effectively ground, and when small enough passes through the holes into the plate and collects in a pit, from whence it is carried up by the elevator to a screen. This consists of a sloping box with a bottom composed of a number of piano wires stretched lengthways. The clay which passes between the wires is conducted into the mixer, while the *tailings*, or larger unreduced lumps, pass over and are returned into the grinding mill. In the mixer the water is added, and the clay worked up to a plastic mass. The mass is delivered into the pug mill, where, after treatment, it is thrust out on to the cutting table, and divided into bricks as already explained. The green bricks by this process have to be dried before they can be put into the kiln. Where possible, this is got over by working the clay semi-dry [5], or by the so-called semi-plastic [4] process.



8. ROBINSON'S HOT-AIR CHAMBER FOR DRYING BRICKS

Machine-moulded Bricks. The pits from which the clay is dug are often very extensive — huge excavations in the earth, sometimes 200 ft. deep. The pit slants gently downwards from the machine house, where the bricks are made, and a number of narrow-gauged trolley lines run down to the bottom of the pit or *clay hole.* The *tubs* or small waggons into which the clay is loaded at the bottom of the pit are hauled up by endless chains worked by a pulley connected with the main shafting. When they arrive at the top of the gradient, the clay is tipped out by an automatic arrangement. As fast as the waggons are emptied, they are run down again into the pit to be filled afresh. The workmen dig at the side or bottom of the pit, and occasionally loosen the clay by firing small quantities of gunpowder at the bottom of bore holes.



9. DOUBLE-CHAMBER SYSTEM OF BRICK DRYING

As the pit is enlarged, care must be taken to remove the earth and soil round the top, so that it does not fall in and contaminate the clay. A good deal of trouble is sometimes experienced by the entrance of water, which must be pumped out when necessary. Indeed, it is almost impossible to continue working during very wet weather.

The clay is first taken to the grinding mill [see 4], a little water being sometimes added to it. The construction of the grinding mill has already been described. The clay is worked so dry that it falls to powder in the hand. As before, it falls through the perforated pan of the grinding mill and is carried up by an elevator, whence it passes through the piano wire screens, and thence to the press. The clay is fed into the mould of the brickmaking machine proper, where it is kept hot by steam. The clay, in a semi-dry condition, is subjected by powerful levers to a pressure of several tons. A brickmaking press is shown in 6.

All sorts of waste materials can be used for making bricks, such as stone chippings, clinker, slate refuse, blast furnace slag, or sand, reduced to a suitably fine powder by powerful machinery, and *bonded* with lime or cement.

The compressed brick is automatically delivered to a table. Sometimes as much as 80 tons pressure is put on the brick, and, although the material was quite powdery as fed into the press, it is now compressed into a solid brick [6], which holds together sufficiently to be handled, and can be put direct into the kiln without previous drying; whereas bricks prepared by the plastic process require to be dried before they can be put into the kiln.

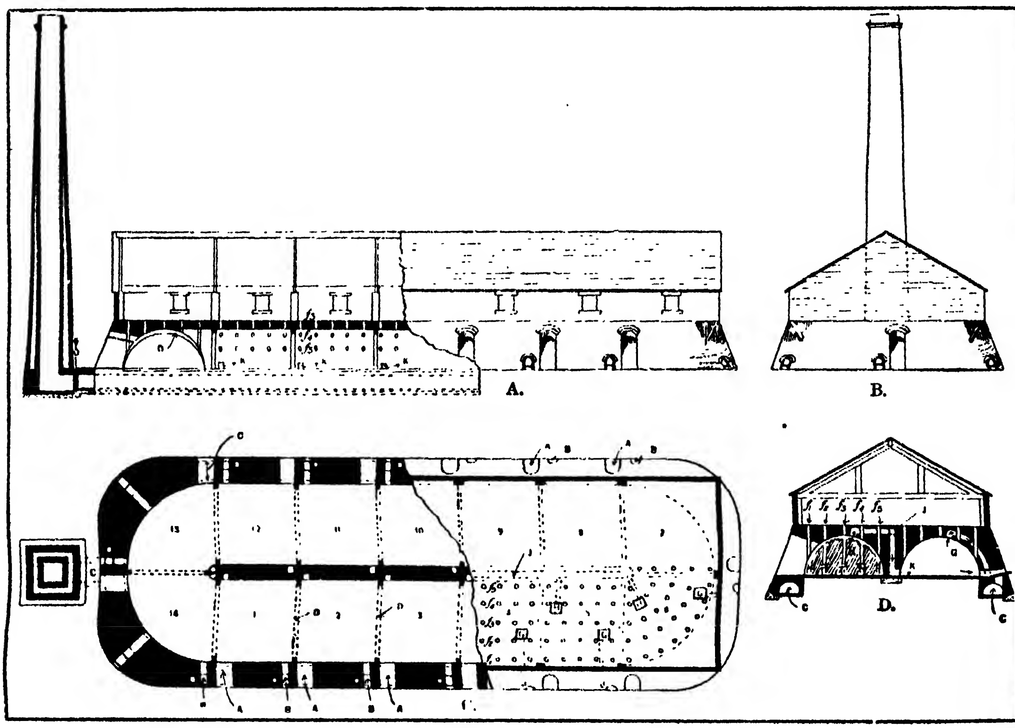
Brick Drying. This drying process used always to be carried out in the air, the bricks being piled upon each other in rows, in such a way as to be exposed to the air as much as possible, and covered with a screen or roof to keep off the direct heat of the sun. If fully exposed to the sun they would dry too rapidly, and would almost certainly crack. There is a tendency, however, to replace drying in the

open by special drying-rooms, one form of which, constructed by E. Robinson, we may now describe.

In the heater [7], the main feature is the spiral *diaphragm.* Steam is admitted inside the parallel system of tubes, and the wind, driven in by the fan, circulates through them, and travels about four times the outside length of the cylinders. The effect of this is to give a very high efficiency, and a large volume of air can thus be heated to 250° F., or higher, if required. Either live or exhaust steam can be used. If the former, a steam trap is connected, so that only the steam actually condensed is used.

A medium-sized heater of this kind is about 12 feet long by 2 ft. in diameter, and its air between them. The fan, not shown here, would be fixed at A [8]. It is represented as viewed from one side. From either side of the heater there is a branch pipe which is carried along the centre of each room. Thus the heater has a separate blast connection into both rooms, and by means of a blast gate on each side the current of wind may be entirely shut off from one room and the whole of it turned into the other room. This construction has the advantage that one heater and fan serves for two rooms, one of which can be cooled down, cleared and refilled, whilst the drying process is going on in the other room.

In one of the rooms [9], a double tier of bricks is seen stacked. The upper tier rests upon shelves of open latticed woodwork. These are



10. OSMAN'S MODIFICATION OF THE HOFFMANN KILN
A. Longitudinal elevation and section. B. End elevation. C. Plan. D. Transverse section

inlet and outlet are attached to suit any desired position. Here it is placed under a floor, as illustrated in **8** and **9**.

For drying bricks in a long, narrow room, as in **8**, a trunk blast-pipe is carried from the heater along the centre, under the floor. This pipe is provided with a series of orifices, so proportioned as to disperse a blast of wind uniformly throughout the whole length of the building. A board of triangular shape is arranged over the discharging orifices, as seen in **9**, and the arrows indicate the way in which the blast is dispersed.

Use of Double Chamber. It will be seen that in the arrangement illustrated in **9** a pair of rooms are built side by side, with a heater standing under the partition readily removed and replaced for clearing or stacking. At B are shown steam-pipes for supplementary heating.

This system of drying applies to wire-cut and such bricks as are handled in the way indicated. It will be understood, however, that this apparatus is equally adapted for what is known as the progressive, or *A B C* mode of working, where the bricks are stacked on cars and run into the dryer on rails. In the latter case it is necessary to excavate t' ground, putting all heating appliances belo and leaving a level surface for the car track. It is generally necessary to supplement any blast system of brick-drying with some steam-pipes under the floor. These are shown at B in **9**. As a rule motive power for driving the fan is

only available in the day time, and it is necessary to maintain some heat. The two independent systems are very convenient for utilising exhaust steam, and when this is turned into the pipes, very little live steam in the blast heater will be sufficient to ensure drying as rapidly as most clays will stand without cracking. By running the fan only during the day, and by allowing the room to cool down at night, bricks of the most delicate clay can be rapidly dried without cracking.

The Sturtevant System. Under ordinary circumstances, a good deal of heat must be left in the kiln gases in order to produce sufficient draught in the chimney. This is economised by the Sturtevant system, which draws these hot gases through drying chambers or tunnels in which the bricks are placed. The induced draught is produced by means of a fan. So constructed, there is no need to build a chimney stack, as the fan creates the necessary draught and has the advantage of being easily regulated. The method is arranged to suit the type of brick. If the latter are very soft they will dry on the floor of the chambers, but it is usually preferable to place them on the shelves of trucks which are run into the tunnels, the hot air passing through lengthways. Some bricks require drying very slowly, while with others the drying may be forced.

Brick Burning. The old method of burning bricks in stacks in the open without any proper kiln, is still largely practised, especially where, in order to meet local requirements, building operations are proceeding on the spot, and the clay deposit is only a small one. The green or unburnt bricks will usually be those made by hand. They are built up into a stack, or pile, with layers of fine coal between layers of bricks. A hole is left near the bottom for firing, and spaces are left to form air-holes and produce the necessary draught. As many as 50,000 bricks can be burnt in one operation. The heaps should be protected from prevalent winds by luting the crevices with clay or placing hurdles thatched with straw against the sides.

The burning takes several days, and the hot gases and flames find their way through the crevices and air-holes, eventually escaping at the top of the heap. As might be expected in such a primitive arrangement, many of the bricks are very unevenly burnt. The temperature on the inside is much higher than necessary, and there bricks are sometimes over-burnt; while on the outside they are not sufficiently heated and are under-burnt.

Burning in kilns is an improvement upon this method. The first kilns were of simple construction, and intermittent in their action—that is to say, when the bricks were burnt the kiln was allowed to cool down, the burnt bricks drawn and replaced by fresh green bricks. As the kiln could not be entered until it had cooled down, most of the heat given off by the cooling bricks was lost.

11. HAND-BRICK MACHINE

Modern kilns are built on the continuous principle—that is to say, the heat given off during burning and cooling serves to drive out moisture and give the preliminary heating to the green bricks. The original continuous kiln was invented by Hoffmann, and the first kiln in this country is said to have been erected at Roundwood Brick Works, near Wakefield, where it is still in use. A modern form of this kiln, as modified by Osman, is shown in the diagram [10].

The Modern Kiln. In principle it consists of an oval framework, roofed in and divided by a centre partition, forming a continuous tunnel, separated into chambers, usually seven or eight on each side, in which the bricks are burnt. The fire travels continuously round these tunnels, and when the heat is at a maximum in, say, chamber 2, the opposite chamber, 9, will be cold. The heat produced in chamber 2, passing on through chambers 3 and 4, etc., heats these in turn; and when the fire has travelled round sufficiently far, chamber 2 will have cooled sufficiently for the burnt bricks to be taken out and replaced by green ones.

The draught is produced by the chimney, but the escaping gases have given up most of their heat in drying and burning the bricks, so that they have cooled to a temperature of 150 to 200° F. before they reach the chimney. The great economy effected will be evident, as none of the heat is lost, and only enough left in the escaping gases to produce the necessary draught.

The fuel is fed into the kiln through small holes, termed *feeding holes*, situated in the arched roof. These are seen at f_1 to f_5 [10], C and D.

The fine coal, or slack, used drops down spaces or pockets left in the bricks as stacked in the chamber underneath. Care is also taken to pile the bricks with spaces between them, so as to allow for the necessary draught; and they are usually arranged in *blades*, or loosely built walls, about 1 in. apart, with spaces about 2 in. wide, termed *traces*, running longitudinally, to take the draught through the bricks.

The Osman Kiln. The Osman kiln shown [10] consists of fourteen chambers. Each chamber has a doorway (A), termed a wicket, through which the bricks are taken when setting or drawing. Each chamber is also provided with what is termed a damper-opening (B), which conveys the draught through the chamber to the main flue (C), running round the kiln under the outside wall, and connected with the chimney. The walls separating the chambers are often temporary, and contain holes corresponding to the traces. As the heat of the chambers is drawn forward it passes through these openings into the next chamber.

Supposing that fire is burning, say, in chamber 1, chambers 2, 3, 4, and 5 may be filled with the green bricks. The dampers corresponding to these chambers will be closed, while 5 will be open, so that the hot gases from 1, passing through 2, 3, 4, and 5, reach the chimney through the flue (C). To prevent cold air in 6 chamber rushing back and checking the draught at 5 damper, the trace-hole openings in the drop wall of 6 are blocked up by pasting paper over them. This paper will gradually burn away when the heat is sufficiently far advanced. When this happens, the damper of 5 is closed and that of 6 opened. The holes in the wall between 6 and 7 are pasted up as before. In this way the heat gradually advances through the chambers; those in front being continuously filled up with fresh green bricks, while those behind are emptied of burnt bricks as soon as they are cool enough. There is an outlet (G) from each chamber, so that the steam gradually driven off from the green bricks is taken from the chamber at the top and drawn into the main flue and away to the chimney. This steam, if allowed to pass through the chambers ahead, would condense on the green bricks, causing them to soften and crush, and would also affect the colour of the brick. It is necessary to draw off this moisture slowly and gently, so as not to crack the green bricks; and to effect this the waste heat through the cooling chambers is drawn upwards through the outlet H, and along a branch flue which joins the central hot air flue at J. The heated air is thence carried down into the chambers at K, containing green bricks, in advance of those actually burnt. The moisture driven off leaves at the point G, reaching the main flue C. When the bricks are taken out they are ready for use.

Fire-clays and Fire-bricks. Such bricks fuse at a very high temperature, and are prepared from special heat-resisting clays. They will stand temperatures at which ordinary bricks would melt and flow like water. Many natural clays are found suitable for their manufacture. They usually consist of silica and alumina, but contain very little iron, lime, or alkalies, as the presence of all these substances tends to lower the melting point of the brick.

Many natural fire-clays are worked for making this class of brick. Such clays are obtained from Dowlais, Stourbridge, and other places.

Dinas Bricks, made from dinas clay found in Wales, consist almost entirely of silica, and artificial bricks have been prepared on the same lines by mixing silica with about 1 per cent. of lime. *Ganister*, a fire-brick of a highly refractory nature, is used for lining furnaces.

Much of the fire-clay used in this country comes from Stourbridge, but excellent material is also obtained from Northumberland, Lancashire, Warwickshire, and South Wales.

Many fire-clays are found underlying coal seams, and are hence frequently termed *under clay*. They are usually of dark greenish-grey colour, and of dense consistency. They are generally mined in the same manner as coal. When brought to the surface, the clay is spread in even layers, and allowed to remain several months, that it may become thoroughly "weathered," after which it is taken to a wash mill and worked until the mass attains a regular consistency. It is run out into settling backs, and when the water has evaporated, the mass is cut up and moulded.

To give an idea of the chemical composition of fire clays, we append the following analysis of Stourbridge clay:

[illegible]	[illegible]
Alumina	22·20
Magnesia	·18
Lime	·14
Oxide of iron	1·92
Potash	·18
Phosphoric acid	·06
Water	9·28
Organic matter	·58
	99·64

Good fire-bricks may be made from the refuse of china clay and quartz sand. Such bricks will consist almost entirely of silica and alumina, with not much more than 2 per cent. of other ingredients.

How to Measure Temperature of the Kiln. It is often of considerable importance, and of great practical interest, to measure the temperatures of the brick kiln, so as to secure even and regular firing—a great desideratum in practical working. The temperature of the kiln is so high that it is not possible to measure it by ordinary thermometers, and there are a number of special devices which are employed for this purpose. Among these, some of the most sensitive and accurate are constructed to work electrically. Many of them depend on the resistance a wire offers to electric current, as the higher the temperature the greater the resistance; but for brickmaking and allied industries simpler contrivances are often used, as, for instance, the Seger cone, which depends for its action on the expansion of a piece of fire-brick when it gets heated in the kiln.

Another appliance is the Watkin Heat Recorder. It is simply a block of very refractory ware, with five recesses or shallow cavities sunk into its top face, in which are placed small pellets of varying fusibility, and of definite composition and melting points. The actual temperature expressed in degrees on the Centigrade and Fahrenheit scales is given in the tables used with the recorders.

They are provided with a special wrapper, which serves to retain the loose pellets in their places, and which is not removed before firing, as it readily burns away. After firing, it does not matter if the loose pellets drop out, as those pieces which fuse will always remain attached to the recorders, and from these the temperatures are read.

CLAYTON BEADLE
H. P. STEVENS

The Principal Characteristics of Mammals. The Modification of their Functional Organs to Environment. Classification.

MAMMALS AND THEIR FOOD

In the last chapter we briefly reviewed the twelve great groups or phyla of the animal kingdom. In the following pages we must examine each group in more detail. The back-boned animals form the first group, and they are subdivided into six classes: 1, Mammals (*Mammalia*); 2, Birds (*Aves*); 3, Reptiles (*Reptilia*); 4, Amphibians (*Amphibia*); 5, Fishes (*Pisces*); 6, Border vertebrates (*Protochordata*).

Mammals. Mammals include all the familiar warm-blooded quadrupeds, together with certain specialised aquatic forms—*e.g.*, whales, which are popularly, but erroneously, regarded as fishes. All mammals breathe ordinary air by means of lungs, and never at any time possess gills. They are more or less clothed with hair, and their young are nourished for some time upon milk. There are fourteen orders, which are set out in their zoological classification on page 1812.

In the earlier part of the Tertiary epoch [see Geology] extensive tracts of marshy ground covered considerable areas in the land-masses occupying the northern hemisphere, and here dwelt a large number of primitive mammals, the ancestors of forms which are now more highly specialised. These creatures were not of large size, and they lived for the most part on vegetable matter, which they chewed up with their relatively numerous (44 in all) and comparatively simple teeth, the crowns of the rather small grinders being provided with crushing tubercles. There were five digits in each extremity; and locomotion was effected in a *plantigrade* manner—that is, on the palms of the hands and the soles of the feet.

Adaptation of Mammals to Natural Surroundings. The swamps just described were to a large extent superseded, as time went on, by extensive plains, covered with grass and other forms of vegetation. These altered conditions led to the evolution, from the primitive swamp-dwellers, of Hoofed Mammals (*Ungulata*) and related forms, suited for comparatively rapid progression on the plains, and adapted to feed on their abundant vegetation, which was drier, and therefore more difficult to chew and digest, than the succulent plants of the marshes and damp forests.

That the hoofed mammals should become more speedy than their ancestors is intelligible when we remember that the Flesh-eaters (*Carnivora*) began to evolve from the same stock at the same time. The struggle for existence is, and has always been, so keen that no sources of food-supply remain neglected; and while some forms have turned their attention to plants, others have preyed upon the plant-eaters. The mechanisms concerned with rapid progression are dealt with later. It will be well to remember that hoofed mammals include *odd-toed* forms (tapir, rhinoceros, horse), and *even-toed* forms (pig, hippopotamus, ruminants), while elephants, conies, and sea-cows constitute three related orders. Gnawers (*Rodentia*), Monkeys and Men (*Primates*), some Mammals Poor in Teeth (*Edentata*), and some Pouched Mammals (*Marsupialia*) also demand attention.

Let us take first the odd-toed hoofed mammals. The tapirs, which superficially resemble pigs, are a somewhat primitive, waning group, now only found in the Malay regions and parts of South and Central America. They still largely adhere to the old swamp life, but are to some extent specialised, their snouts being drawn out into a short proboscis, and their grinding teeth ridged—a useful improvement upon projecting tubercles.

The Horn's Twofold Use. The rhinoceroses of Africa and South Asia are a step in advance of the tapirs, their teeth being more or less reduced in number, and the crowns of the large grinders having a more complex set of ridges, converting them into a very efficient masticatory apparatus. One or two horns—in the latter case one behind the other—are borne on the snout, and are said to be used for grubbing up vegetable food. Their large size, enormous strength, formidable horns, and thick skins also render these creatures practically immune from the attacks of the flesh-eaters.

Horses, asses, zebras, and quaggas are remarkable for their speed (the ass must not be judged in this respect from the familiar "moke") and gregarious habits, which go far to protect them from enemies. Their teeth show increased complication, the grinders possessing elaborately ridged crowns, and, being composed of three materials of different degrees of hardness, always keeping rough—a great point when somewhat dry vegetable food has to be chewed. Canine teeth are practically absent, though often feebly represented in the stallion, and the front teeth (incisors) are provided with deep pits, which get filled up with food, resulting in a black "mark" on the crown, which is a practical guide to age.

The Large Family of Pigs. Consider now the even-toed hoofed mammals. The widely distributed swine—represented in America by the peccaries—are, in some respects, the most primitive members of their order, as shown by their fondness for marshy ground, their full number of teeth, and the tubercles on the crowns of the grinders. They are omnivorous.

The well-known hippopotamus of Africa (there is also a small species in Liberia) is practically a huge pig, which spends most of its time in rivers, and is a vegetarian pure and simple. But its dentition is somewhat special-

ised. The pig is familarly associated with Ireland, as being the "gintleman that pays the rint," and it is interesting to observe that the ridges of a worn grinder of the hippopotamus are arranged in a double-shamrock pattern.

Chewing the Cud. Ruminants (Cud-chewers), a group of the even-toed hoofed mammals, include deer, oxen, sheep, goats, antelopes, giraffes, and camels, with their allies. Rumination, or chewing "the cud," is a somewhat peculiar digestive process, which in effect means the power of swallowing a hasty meal, retiring to a place of safety, and then bringing back the said meal in successive portions ("boluses") to the mouth, to be carefully chewed, swallowed, and digested. This arrangement is associated with a complicated four-chambered stomach (portions of which are familiar to eaters of "tripe"), consisting of (*a*) the paunch (*rumen*), (*b*) honeycomb stomach (*reticulum*), (*c*) manyplies or psalter (*omasum*), and (*d*) reed or rennet stomach (*abomasum*). The food is first hastily cropped, without chewing, and passes into the paunch, from which it goes into the honeycomb stomach. Here it is made up into rounded boluses, and returned into the mouth. After careful chewing, it is once more swallowed, and now enters the manyplies, which has numerous leaf-like folds, and serves as a strainer. Thence it passes to the reed, where it is subjected to the chemical action of the gastric juice, and ultimately reaches the intestine, there to be further digested and absorbed.

In all ruminants, except camels, and the related llamas and alpacas of South America, the upper front teeth (including the canines) have disappeared. In the ox, for example, the lower front teeth bite against a horny pad on the upper jaw, and it may be added that the grinders possess flat crowns with a fairly complex arrangement of ridges, making them efficient millstones.

Distinctive Features of the Elephant. Elephants (*Proboscidea*), which inhabit Africa and South Asia, are well-defended herbivores, that are in some respects primitive in structure, though their teeth and trunk are remarkably specialised. There are no front teeth, except two upper incisors, which are elongated into formidable tusks, serviceable as defensive weapons, and also employed for grubbing up succulent roots. The huge and complicated grinders succeed one another from behind forwards, instead of from below upwards, as in other cases. In an adult animal, only four of them are in place at the same time. The crowns of these great teeth possess a series of lozenge-shaped ridges in the African elephant, and more numerous narrow transverse ridges in his Indian cousin.

The trunk of an elephant, which is no more than a nose drawn out into a complex and delicate manipulatory organ, largely compensates for huge bulk and strong, pillar-like legs, which serve simply as organs of support. By its means tree-branches on the one hand, and herbage on the other, are easily secured as food. A series of fossil forms discovered in the Egyptian Fayûm show how the trunk gradually evolved.

Sea-cows (*Sirenia*) are related to the elephant order. The dugong and manatee, mentioned already in this course, are probably to be regarded as an ancient offshoot from the ungulate stock, which have become adapted to a vegetarian aquatic life, have lost their hind limbs, and simplified their teeth. A gigantic toothless member of the order (*Rhytina*) formerly lived on the islands of the Behring Sea, and only became extinct, through the agency of man, in the eighteenth century. In certain fossil forms the remains of the hind limbs are better developed than in the existing types.

Specialised Teeth of Gnawers. The large order of Gnawers (*Rodentia*) mostly consists of small and comparatively simply organised mammals, found in nearly all parts of the world, though their headquarters are in South America. Forms familiar in Britain are the rabbit, hare, squirrel, rat, and mouse. Taking the rabbit as a type, we shall find two chisel-edged incisors above and below, no canines, and a number of prismatic grinding-teeth with transversely ridged crowns. All of them grow continuously throughout life. The incisors remain sharp because they are thickly coated in front with relatively hard enamel, the rest of them being mostly made up of dentine or ivory, which is not so hard. Hence they wear unequally, and maintain a sharp edge. As the teeth are constantly growing, constant gnawing is necessary to keep them worn down; and if an unfortunate animal happens to lose an incisor, the one which normally should bite against it grows to an inordinate length, and ultimately causes the death of its unfortunate possessor.

Tree-dwellers. Squirrels are interesting because they have become adapted to an arboreal life. Their long, bushy tails serve as balancing organs. The water-rat and its smaller relatives (voles) possess comparatively complex grinding-teeth. Rats and mice are distinguished by their omnivorous habits, and are to be found in almost all parts of the world. Of non-British members of the order, beavers, porcupines, capybaras, and chinchillas may be mentioned. Beavers, as is well known, are able to fell trees with their gnawing front teeth, and in this way construct dams across rivers, on the upper side of which they make rounded "lodges," sunk beneath the surface and entered by an opening reached by diving.

The ground porcupines of the Old World, and the climbing porcupines of the New, possess defensive quills which serve as an effectual protection against most enemies, and are in reality modified hairs of large size. The capybara, a native of South America, is the largest existing rodent, being about as big as a medium-sized pig. Its molars are large and complicated, and it is of aquatic habit. The little chinchillas of the high Andes are noted for the soft fur which they yield.

Monkeys (*Primates*) are arboreal forms native to the warmer parts of both hemispheres, and of predominatingly vegetarian habit, though some of them (and man) are omnivorous. As compared with more typical mammals,

the teeth are somewhat reduced in number (32 in all), and the crowns of the grinders are tuberculated. In some of the leaf-eating monkeys the stomach is of complicated nature, as this kind of food is rather difficult to digest.

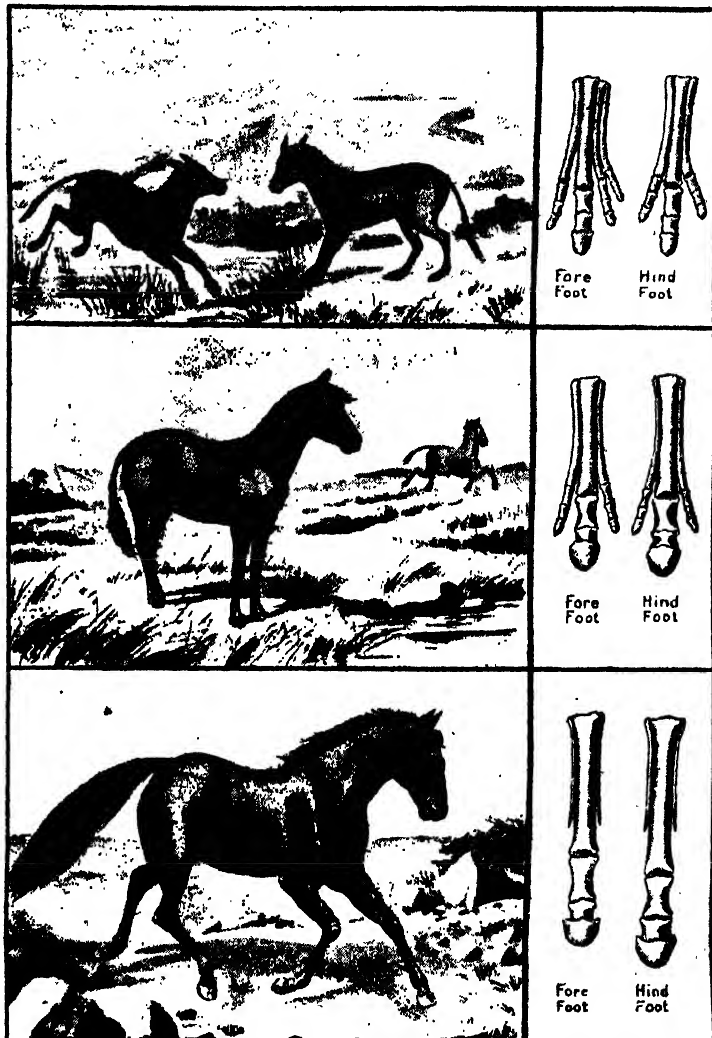
Mammals Poor in Teeth. An ancient order is that of Mammals Poor in Teeth (*Edentata*), now on the down grade. The sloths of South America are arboreal leaf-eating forms, which hang head downward from tree-branches by means of their long, hook-like claws. In comparatively recent geological times huge ground-sloths lived in South America, which were too big to climb trees, but were strong enough to uproot them in order to feed upon their foliage.

In the primitive order of Pouched Mammals (*Marsupialia*) there is not a regular succession of two sets of teeth, as in higher mammals, and only the first grinder appears to have a regular successor. The arboreal opossums of America are omnivorous, and a number of the Australian members of the order are pronounced vegetarians. The springing kangaroos and their allies browse upon grasses and herbs; the wombats burrow, and gnaw roots by means of their rodent-like incisors; tree-kangaroos and phalangers are arboreal, and the latter live largely upon fruit. The little mouse-phalangers possess long, slender tongues, which they insert into flowers to secure nectar, and probably small insects as well.

Carnivorous Mammals. There are five orders, all or most of the members of which live upon animal food—*i.e.*, Insect-eaters (*Insectivora*), Bats (*Chiroptera*), Whales and Porpoises (*Cetacea*), Flesh-eaters (*Carnivora*), and Egg-laying Mammals (*Monotremata*). Carnivorous forms are also to be found among the Mammals Poor in Teeth (*Edentata*), and the Pouched Mammals (*Marsupialia*).

Insect-eaters. Some of the small nocturnal animals which make up the order of Insect-eaters are to be found in almost all parts of the world except South America and Australia. They may be said to play much the same part in regard to the minor varieties of animal food that gnawers do with reference to vegetable food, and, like them, are of simple organisation.

The familiar European Hedgehog (*Erinaceus europæus*) is a good type of a group of the order which is pretty common in the Old World, and has allies in the West Indies. In accordance with the nature of its food, which mostly consists of worms, snails, insects, and other small



THE EVOLUTION OF THE HORSE FROM A SWAMP-DWELLER TO A PLAIN-ROAMING MAMMAL

The top picture shows the eohippus, which ran on four and three divided toes. The centre picture is miohippus, and the bottom the modern horse. The skeletons of the animal's feet clearly indicate the course of its evolution.

creatures, the teeth of the hedgehog are sharply pointed, those at the back having their crowns provided with small cutting projections. Such teeth are eminently suitable for dealing with the small animals named, as well as with snakes and other reptiles, frogs, and even mice, none of which creatures are despised as articles of diet. The name "hedgehog" has been suggested

by the shape of the snout, which is something like that of the pig, and is used in much the same way for grubbing in the ground.

The Smallest Mammal. Shrews are very small, mouse-like creatures, having a very wide distribution. There are three species native to Britain, two of which are our smallest mammals, while the group is notable for the fact that some of its members are more diminutive than any existing mammals whatsoever. A body less than an inch and a half in length, plus an inch-long tail, is about the record. The teeth of a shrew are very like those of a hedgehog, but its snout is much more slender. Jumping shrews, little, desert animals, are native to Africa, and are adapted for springing, their hind legs being much elongated.

While the insect-eaters so far named hunt for their food on the ground (except water-shrews), there are tree-shrews that are arboreal. In appearance they somewhat resemble squirrels, and are native to South-East Asia.

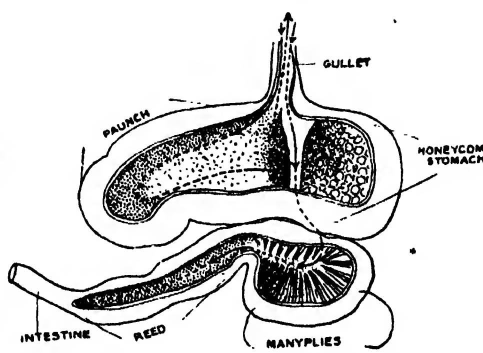
Among aquatic insect-eaters, the desmans inhabit some of the rivers of the Old World, such as the Volga, and are larger than the average of their kind. The snout is drawn out into a short proboscis, well adapted for searching out food in the crannies of river banks. In West Africa, an animal (*Potamogale*) has been found in some of the rivers which might easily be mistaken for a small otter, but is really a member of the present order. The resemblance results from adaptation to a similar mode of life.

A Hungry Underground Hunter. The well-known Mole (*Talpa europœa*) is beautifully specialised for the pursuit of earthworms and other small animals underground, and is one of the hungriest and most untiring of hunters, far excelling lions and tigers in these respects. It belongs to a group which is characteristic of the north temperate zone, and has allies (golden moles) in Africa.

The members of the ancient and almost ubiquitous order of insectivora have become adapted to the pursuit of small prey on the ground, in fresh water, among trees, and in the earth. The closely related Bats (*Chiroptera*) have acquired the power of flight, and wage incessant warfare in the air against such members of the insect tribe as come out at dusk. That part of the flying membrane which stretches between the hind limbs and tail can be turned forwards and used as a very effective sweep-net. Bats are found all over the world.

There can be no doubt that Whales and Porpoises (*Cetacea*) have descended from terrestrial ancestors, but their exact line of descent is somewhat doubtful. Some members of the order possess numerous sharp simple teeth, which are eminently suitable for seizing and holding slippery fishes and cuttle-fishes. The common porpoise (*Phocœna communis*) is one of the most familiar forms—indeed, too familiar, for it is a great enemy of the fisherman, not only on account of its appetite, but because it damages his nets and frightens away his lawful booty. The huge sperm whale, or Cachalot (*Physeter*), is an example of a toothed cetacean on a large scale.

The Source of Whalebone. The whalebone whales, which include the monsters of the order—up to 85 feet—have no functional teeth, though in very early life these are to be found imbedded in the gums, which, however, they never cut. The most noteworthy peculiarity of these forms, as seen familiarly in the Greenland whale (*Balæna mysticetus*), consists in the presence of numerous pairs of horny plates (*baleen*), frayed out at the edges, which hang down from the roof of the mouth. The so-called "whalebone" is derived from them. The whales of this group feed upon the small animals which float in enormous numbers at or near the surface of the sea, making up what is technically called "plankton." Moving along at some speed, the whale takes in large quantities of sea-water, which is strained through the baleen, leaving behind in the mouth the numerous small creatures it contains. The danger of choking during this process of feeding is obviated by the fact that the top of the windpipe is drawn out into a cone, which fits into the back of the nasal passages in such a way that no water can find its way into the lungs.



SECTION THROUGH THE STOMACH OF AN
The course of the food is shown by arrows

Flesh-eaters (*Carnivora*) are descended from the same ancient swamp-dwelling stock as hoofed mammals, but claws have been evolved instead of hoofs, and the teeth are more or less suited to flesh-eating. Seals, sea-lions, and walruses have become adapted to an aquatic life.

Bears (*Ursidæ*), with the exception of the Polar bear (*Ursus maritimus*), are of omnivorous habit; and though the canine teeth are in the form of prominent tusks, the back grinders have blunt crowns, suitable for dealing with a miscellaneous diet. These creatures exhibit the primitive character of being plantigrade.

The remaining land carnivores are typically *digitigrade*—that is, they walk on the ends of the fingers and toes, and their back teeth are mostly compressed, and possess cutting crowns.

The omnivorous badger (*Meles taxus*) and its immediate allies are the least specialised members of the group, and in many respects resemble bears in structure. But weasels, stoats, sables, martens, and the like are eminently carnivorous

and bloodthirsty. None of them are of any great size, and the narrow, short-legged body is well suited for penetrating undergrowth. Some are arboreal, and the weasel makes its way underground to attack burrowing mammals, such as moles and field-voles. The otter (*Lutra vulgaris*) is a predaceous aquatic member of the group, with sharp-pointed teeth, adapted for seizing fish. In the rare sea-otter (*Enhydris*) of the North Pacific the back teeth have blunt crowns, in accordance with the diet, which consists mainly of sea-urchins, crabs, and shell-fish, all of which need to be crushed.

The Raccoon and Coati Family. The small animals of the Raccoon and Coati Family (*Procyonidæ*) are nearly all American, and the best-known forms are the raccoon (*Procyon*) and the coati (*Nasua*). The former lives a good deal among trees, but also hunts for prey in brooks. It is remarkable for the curious habit of washing its food. The long-snouted coati is largely arboreal, and hunts down tree-lizards, but it also frequently descends to the ground to grub up worms and other small creatures with its snout.

The Dog Family. The members of the Dog and Wolf Family (*Canidæ*), including jackals and foxes, are very widely distributed, there even being a sort of dog—the dingo—in Australia. These creatures are more specialised than bears, but less so than the cats and their allies. Wolves and wild dogs hunt in packs, and track their quarry by smell.

Civet-cats, Genets, and Mungooses. The family of Civet-cats and Mungooses (*Viverridæ*) includes a large number of small animals which are well adapted to a carnivorous life, but not so highly specialised as the cats proper. The civet-cats (*Viverra*) are nearly all ground animals, mostly from South Asia, but also represented in Africa, to which continent their relatives, the genets (*Genetta*), are almost entirely confined. The Indian palm-civets (*Paradoxurus*) live in trees, and not only prey upon various small animals, but also eat fruit to some extent. The mungooses (*Herpestes*) are small African and South Asiatic animals, somewhat resembling stoutly built weasels, and remarkable for their extreme agility, which enables them to cope successfully with poisonous snakes.

The comparatively large Hyænas (*Hyænidæ*), closely related to the civet-cats, feed mostly upon carrion. The striped hyæna (*Hyæna striata*) of Asia and Africa, and the spotted hyæna of South Africa (*Crocuta maculata*), have immensely powerful jaws and teeth, with which they can easily crunch up bones. The aardwolf (*Proteles*) of South Africa is a kind of degenerate hyæna, with reduced and comparatively feeble back teeth. It burrows underground, and devours termites (white ants) as well as carrion.

The Cat Family. The Cat Family (*Felidæ*) includes the beasts of prey *par excellence*, such as the lion, tiger, leopard, and cheetah of the Old World, and the puma and jaguar of the New. The domestic and other "cats" also belong here. Examination of the skull of a lion will show some of the specialisations that exist in connection with the carnivorous habit. The jaws are of enormous strength, and the prominent ridges on the skull are partly for the attachment of muscles that work the lower jaw up and down. The canine teeth are exceedingly powerful tusks, and are used in seizing and holding prey, while the crowns of the back teeth perform the function of cutting blades of great efficiency.

As is familiarly known, the claws of cat-like animals are employed against their victims with deadly effect, and when not in use are drawn back into sheaths, and thus prevented from becoming blunt. They are sharpened by being rubbed against trees. Sight and hearing are very acute in members of the group, all of which stalk their prey, finally securing it by a sudden rush or spring.

The Sea-dwelling Flesh-eaters. Of the three families belonging to the subdivision of Aquatic Carnivores (*Pinnipedia*), one includes the walrus (*Trichechus*), which has enormous tusk-like upper canines, and grinders with blunt crowns. The former are used for grubbing up shellfish as food from the sea-bottom, and the latter for crushing them. The sea-lions and seals, which make up the two other families, are fish-eaters, and the crowns of their back teeth are laterally flattened and sharply pointed. In all these aquatic forms the limbs are in the form of paddles.

Mammals Poor in Teeth. The Mammals Poor in Teeth (*Edentata*) include the great ant-eater (*Myrmecophaga*), adapted to feeding on insects, much in the same way as the spiny ant-eater. With its enormous claws it is able to tear open ant-hills in pursuit of its prey. The Cape ant-eater, or aardvark (*Orycteropus*) of South Africa (which possesses back teeth), and the scaly pangolins (*Manis*) of Africa and South Asia, are both specialised in a similar fashion to the great ant-eater.

Australian Pouched Mammals. Among the Australian members of the Pouched Mammals (*Marsupialia*) order we find carnivorous forms which superficially resemble species belonging to various other orders, the resemblance having been brought about by adaptation to similar modes of life. Such are the native "wolf" (*Thylacinus*) of Tasmania, the dasyures (resembling civet-cats), the banded ant-eater (*Myrmecobius*) (which, however, possesses unusually numerous teeth), and the pouched mole (*Notoryctes*).

The Mammals that Lay Eggs. Egg-laying Mammals (*Monotremata*) include the spiny ant-eater (*Echidna*) and duck-billed platypus (*Ornithorhynchus*), which are both carnivorous. The former possesses a narrow, toothless snout, and its long, sticky tongue secures insect prey. The duck-billed platypus lives in streams, feeding largely on water-snails, which it is able to crush by means of horny plates in its jaws.

CLASSIFICATION OF THE ORDERS OF THE MAMMALS

1. Men and Monkeys (*Primates*). All the members of this order are distinguished by the possession of a relatively large brain, and this affects the general shape of the skull, one result being that the eyes are directed to the front. Man alone excepted, these highest mammals are adapted for a climbing, tree life, and their feet are grasping organs.

MAN-LIKE APES. These approach more nearly to man in structure than the other members of the order, and, unlike these, can walk on their hind limbs with more or less facility. The gorilla and chimpanzee are native to tropical Africa, the orang-utan to Sumatra and Borneo, and the gibbons to south-east Asia. These, and the very numerous monkeys of the Old World, have comparatively narrow noses, thus differing from the broad-nosed monkeys of America, many of which also possess prehensile tails. In the latter group, too, are included the little marmosets.

2. Lemurs (*Lemuroidea*). These are small, monkey-like creatures, included by some authorities in the last order, but decidedly lower in the scale. They inhabit the tropical forests of the Old World, most of them being peculiar to Madagascar.

3. Insect-eaters (*Insectivora*). The members of this large and ancient order are small animals found more or less in nearly all parts of the world, and adapted by their structure to feed upon insects and other small creatures. Of British species, the hedgehog, mole, and shrew belong here.

4. Bats (*Chiroptera*). These are closely related to the insect-eaters, from which they differ in the possession of organs of flight. The larger bats of the East Indies are fruit-eaters.

5. Gnawers (*Rodentia*). Here, again, we have a large, ancient, and widely distributed order, including animals that are mostly small, and generally adapted for living upon vegetable food, though some are omnivorous. They possess four chisel-edged front teeth (incisors), which grow continuously throughout life. Of familiar British types, rabbits, hares, voles, rats, mice, and squirrels illustrate the wide variations in habit that characterise the order.

6. Hoofed Mammals (*Ungulata*). This group includes most of the large herbivorous forms, as well as a few omnivorous ones, and the hoofed extremities are more or less adapted for swift progression. The odd-toed and even-toed ungulates are respectively distinguished by an odd and even number of digits on the hind foot.

ODD-TOED UNGULATES. The pig-like tapirs of south-east Asia and tropical America possess four toes on the fore and three on the hind foot, while the rhinoceroses of Africa and South Asia have only three on each. In horses and their allies there is but one large toe on each foot.

EVEN-TOED UNGULATES. The omnivorous swine and the plant-eating hippopotamus of Africa do not chew the cud, and thus differ from the ruminants, among which are included deer, oxen, sheep, goats, giraffes, camels, and llamas.

7. Elephants (*Proboscidea*). These huge plant-eaters, native to Africa and South Asia, are in many ways simpler in structure than the members of the last order, but their teeth are much specialised, and the prehensile trunk, into which the snout is drawn out, is a notable peculiarity.

8. Conies (*Hyracoidea*). This order includes some small creatures, sometimes confounded with rabbits, inhabiting the African and Syrian deserts. There are four toes in the fore-foot, and three in the hind, all provided with small hoofs, except the innermost hind toe, which is clawed; upper incisors like those of the rabbit; back teeth something like those of the rhinoceros.

9. Sea-Cows (*Sirenia*). This group of plant-eating marine mammals is represented only by the dugong and manatee, which haunt the shores and estuaries of the Indian Ocean and South Atlantic respectively. The tail is horizontally flattened, the fore limbs are modified into flippers, and the hind limbs have disappeared entirely.

10. Whales and Porpoises (*Cetacea*). These are even more fully adapted to an aquatic life than the sea-cows. Some, such as the porpoise and sperm-whale, possess numerous pointed simple teeth, but the whalebone whale and its allies are entirely toothless.

11. Flesh-eaters (*Carnivora*). Here are included a great variety of predaceous forms, possessed of strong tusks, or canines, cutting back teeth, and clawed digits.

The CAT FAMILY (*Felidæ*) embraces the species best adapted for a carnivorous life, such as the lion of Africa and India, the tiger of Asia, and so on. The hyænas of the Old World make up a closely related group.

The DOG FAMILY (*Canidæ*) includes dogs, wolves, foxes, and jackals, which are not so specialised as the preceding family.

The WEASEL FAMILY (*Mustelidæ*) is represented by many small bloodthirsty forms, such as weasels, and by the larger otters, which are equally rapacious. The omnivorous badgers also find a place here.

The BEAR FAMILY (*Ursidæ*). With the exception of the Polar bear, the members of this family are omnivorous, and less specialised in structure than most other flesh-eaters.

AQUATIC FLESH-EATERS (*Pinnipedia*). These are the walruses, sea-lions, and seals, all of which are well adapted to a marine life, as may be seen by their shape and their flipper-like extremities.

12. Mammals Poor in Teeth (*Edentata*). Living in South America are a number of archaic forms, which are the chief living examples of this decadent order, that is also represented, however, in the Old World. They include the toothless great ant-eater, the burrowing and armoured armadilloes, and the leaf-eating arboreal sloths.

13. Pouched Mammals (*Marsupialia*). Except the American opossums, the members of this primitive order are natives of the Australian region, where, in the absence of competing higher types, they have acquired an extraordinary diversity of character, adapting themselves to the most varied habits. The native "wolf," for instance, is a flesh-eater; the banded ant-eaters are insectivorous; the little pouched mole feeds on various small creatures; the springing kangaroos are herbivorous; the burrowing wombat devours roots, and the climbing phalangers eat fruit. The young of marsupials are born in a very immature condition, and are sheltered for some time in a pouch formed by a fold of skin on the under side of the mother's body.

14. Egg-laying Mammals (*Monotremata*). This order includes only the duck-billed platypus and spiny ant-eaters of Australia, which are much more primitive in structure than any other existing mammals, and present many points of resemblance to reptiles. The most extraordinary fact in regard to them is that they lay eggs, though the young, when hatched, are fed on milk, as in the other orders. The milk-glands, however, are devoid of teats, and their secretion oozes into a depression, from which it is licked up.

J. R. AINSWORTH-DAVIS

Properties of Series Motors. Control of Tramway Motors. Tramway-car Brakes. Overhead Construction.

ELECTRIC TRAMWAYS

One of the earliest industrial applications of electricity was to the driving of tramways. The first electric tramway was installed by Siemens, of Berlin, in 1882; and the system was quickly taken up and brought to a high state of development by American engineers, owing to the bad roads rendering this form of suburban and inter-urban locomotion practically the only possible one. It is remarkable that the system of traction early adopted is the one which commands practically universal acceptance until the present date. It consists essentially of (*a*) a supply of *continuous current* at 500 to 550 volts, generated in (*b*) a *central power-house*, and transmitted to the cars by means (*c*) of *overhead conductors*, whence by contact with a trolley wheel on a pole on the car it is led down to (*d*) *two series-excited motors*, which are placed electrically first *in series* with one another *at starting*, and then *in parallel* with one another when a sufficient speed has been attained.

Tramway Systems. The principal recent modifications are the substitution of a supply of current from sub-stations where a high voltage alternating current is converted to continuous [see Systems of Supply], and the adoption of underground conduits or of methods of surface-contact in place of overhead wires. A few lines are, indeed, operated by alternating currents, but they are exceptional. The chief technical interest, therefore, turns on the application of continuous currents by the use of two series-excited motors on the car, as it is this particular combination which has shown itself best adapted to the needs of tram-car propulsion. These needs are, in the first place, a great starting effort when the car begins to move; and, secondly, means of changing the propelling effort as required by the changes of speed and the exigencies of ascending or descending gradients. Attention must therefore be first directed to the properties of the motor, and then to the methods of electrically controlling its speed, its effort, and the amount of current which it draws from the lines.

The Series excited Motor. On page 1153 we discussed the different methods of exciting the field-magnets of generators. The same arrangements can be used for exciting motors, though, of course, the motors will have different characteristics of working when used under the different conditions.

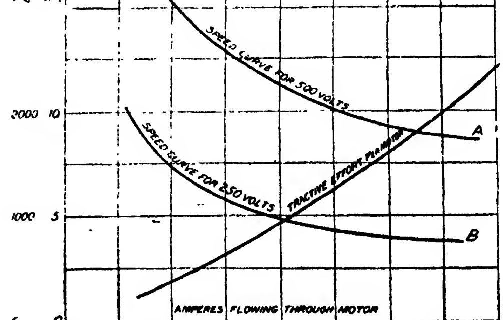
Just as the shunt dynamo is the one principally used at the present day, so the shunt motor, with the notable exception of traction work, is almost exclusively used for power purposes. The article beginning on page 1417 was taken up wholly with a discussion of the shunt motor; we have now to study the series motor in connection with its only present-day application.

The characteristic properties of a series motor are generally considered with reference to the current which it takes, and are expressed in the form of curves, such as are shown in **139**.

To help in the study of these we may classify in parallel columns the properties of the series and the shunt motor as follows:

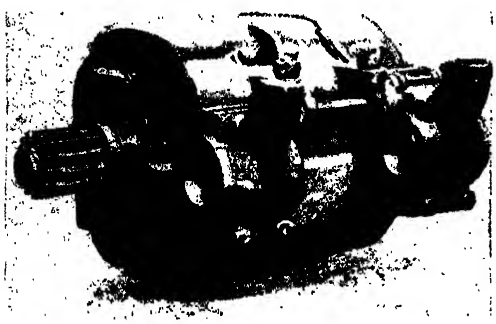
Shunt Motor	Series Motor
The *speed* is practically constant at all loads, and therefore independent of the current which flows through the armature.	The *speed* varies, and is high with a small current and vice versa, because the magnetism is created by the same current which eventually flows through the armature, and therefore alters with it, and a high speed is necessary to generate the same voltage with a smaller amount of magnetism.
The *torque* [page 1418] or *tractive effort* is directly proportional to the current, again because the magnetism is constant.	Because the magnetism increases with the current, the *tractive effort*, which depends upon both the magnetism and the armature current [see page 1418], is relatively greater with large currents.

It is the combination of these two qualities which makes the series motor so valuable for



139. CHARACTERISTICS OF SERIES MOTOR

traction purposes, for, at starting, when the greatest tractive effort is required, this effort is greater per unit of current than it would be with a shunt motor, and the natural speed of the motor is low when a large pull is required.



140. TRAMWAY-CAR MOTOR
By courtesy of Messrs. Witting, Eborall & Co.

Construction of Tramway Motors. The manufacture of tramway motors is an art which has been acquired only after years of experience. A minimum amount of space is available underneath the car, and the motor has to be totally enclosed to protect it from the weather. The construction of the various parts must be without fault, for they have to withstand the heavy strains ranging from an expeditious starting-up under the maximum load, to those due to an emergency braking.

The motor itself is invariably of a four-pole design, and a typical example is illustrated in **140**, **141**, **142**, and **143**. Fig. **140** gives a view of the complete motor ready for mounting on its truck. The box-like casing, which also serves as the yoke of the magnetic circuit, is of the best cast steel, and is made in two parts, which are hinged so that it can be conveniently opened for examination, as in **143**. With one half of the box are cast the brackets which form the bearings of the car-axle and other details necessary in mounting the motor [**140**]. In tramway work the motor is never placed directly on the wheel axles, but drives through a reduction spur-wheel gear, the ratio of the speed of the motor to that of the wheel axle being from 3·5 to 1 to about 5 to 1. By adopting this arrangement the motor may be mounted on springs [**141**], which take up all the jolts and jars from the road, and thus ensure the protection of the motor to a considerable extent.

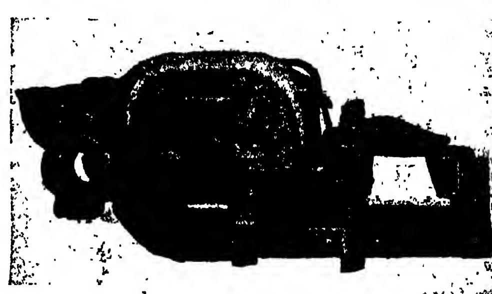
To minimise the energy-losses in the iron of the magnet core, it is generally built up of laminations riveted together. In the motor shown there are four magnet-poles. Two of these, marked MM in **143**, are in the lid, the other two are in the lower part underneath the armature A. The pole-cores are as short as possible, and the exciting coils EE are wound on formers to such a shape as to make best use of the space available between the poles and the case. The armature A [**143**] is always wave-wound [see page 1149], so that only two sets of brushes are needed [**74**, page 1151], and in this way the whole of the brush-gear becomes easily accessible for inspection and repair, as in **143**. The brushes BB themselves are of carbon, covering two or three commutator segments, and are fixed once and for all in the neutral position [page 1151], because the motor is required to run in both directions.

When the motor is closed, they press on the commutator C at parts distant from one another by a quarter of the periphery. P is the pinion of the speed-reducing gear.

The laminations of the armature are extra thin, and are carefully selected for their magnetic qualities. The slots in the tramway motor armature are relatively larger and fewer than in other types, for by this means the total space taken up by insulation is somewhat reduced.

Until a few years ago the normal rating of tramway motors was 20 to 25 h.p., the rating being determined by the output which could be taken from the motor for one hour's continuous run without the temperature-rise in any part exceeding 135 deg. Fahr. (75 deg. C.) over the surrounding atmosphere. The introduction of larger cars such as those used by the London County Council, with top-covers, has created a demand for larger motors. Messrs. Dick Kerr & Co., Ltd., and other makers, now supply a 40 h.p. size. This is fitted, in the case of Messrs. Dick Kerr's motor, with interpoles or auxiliary poles, as described in page 1152, for the purpose of reducing the possibility of sparking, and of obtaining the largest output for a given weight of motor.

The Control of Tramway Motors. We have already said that tramway motors are connected in series at starting, and afterward in parallel. The reason is one of economy, for at the start the value of the current is controlled solely by the insertion of resistance in series with the motor, just as in the case of the shunt motor [page 1420], and we may just as well let the same current pass in succession through both motors as take double the current from the line



141. MOTOR, SHOWING SPRING SUSPENSION

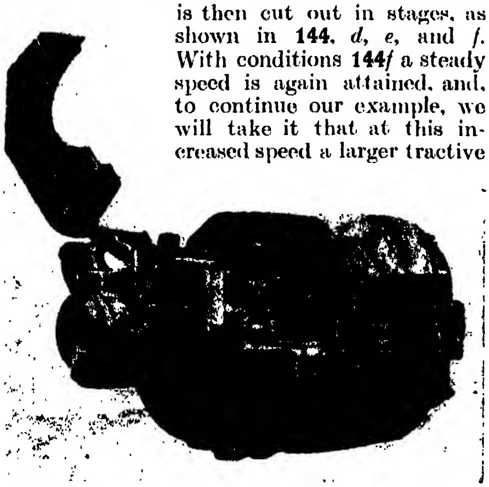
and send it in two branches through the two motors. The various stages in the control which follow are diagrammatically shown in **144**. After the car has once started moving, the next operation is to cut out the resistance, generally

in three stages, for the current value becomes more and more determined by the speed of the motor than by the resistance in series with it. When all the resistance is short-circuited [144c] the car gradually attains a steady speed, and the current consumed will be that necessary to provide a tractive effort in the two motors which is just sufficient to overcome the running friction of the car.

Suppose in our motors [139] that this tractive effort were 1000 lb., this being divided equally between the two motors, we see from the curve that for a tractive effort of 500 lb. each motor is requiring 25 amperes, and that according to the curve B, which represents the relations for series connections, the speed will be work out at 6·2 miles per hour.

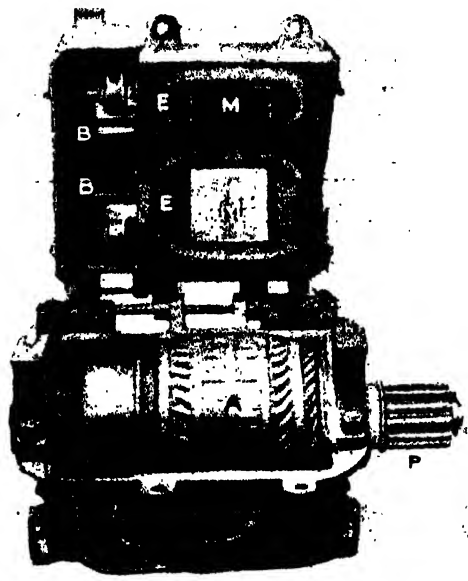
Parallel Connections for Top Speed. Under certain conditions—for example, on a long hill—it is advisible to continue to run with the motors in series, but often a higher speed is required. We put the motors in series to economise current at starting; we now put them in parallel to attain a high speed when the car is well under way, for the speed is dependent on the voltage, and when they are running steadily in series the voltage on each motor is about 250, while if we could get them running steadily in parallel—that is, each straight across the mains—the voltage across the terminals of each would be 500, and a high speed would result, as shown in the upward curve [139].

The transference of the motors from series to parallel must be done in stages, for resistance must first be introduced to limit the rush of current which takes place when the motor connections are altered from the position in 144c to that shown in 144*d*. This resistance is then cut out in stages, as shown in **144**, *d*, *e*, and *f*. With conditions **144*f*** a steady speed is again attained, and, to continue our example, we will take it that at this increased speed a larger tractive effort of 1500 lb. is required. With 750 lb. effort per motor we see [139] that about 34 amperes are required per motor, and this time twice this amount—namely, 68 amperes—will be required from the line. Referring to curve A, we also see that the speed corresponding to these 34 amperes per motor, will now be about 12 miles per hour.



142. MOTOR: END COVER OPENED, SHOWING COMMUTATOR AND BRUSHES

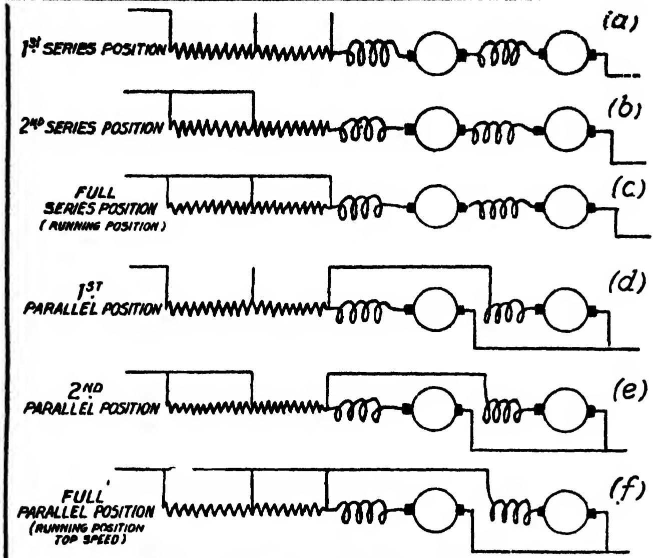
The Tramway Controller. The modern tramway controller is a model of ingenuity. Its usual appearance is shown in **156**. It is really a series of switches, which by successive movements place the two motors first in series, and then in parallel with each other, there being several stages in each operation, as explained above. Further rotation of the main handle disconnects both motors from the circuit, allowing them to run as generators through suitable resistances. In these circumstances they act as very efficient brakes, forming a very useful addition to the ordinary wheel brake. The two motors are finally short-circuited. The movement of a smaller handle—which is so interlocked that it will move only when the main handle is in the correct position—enables the motors to be reversed. Finally, an electromagnetic circuit is so arranged that all circuit brakes are made in a magnetic field which blows out the arcs immediately they are formed.



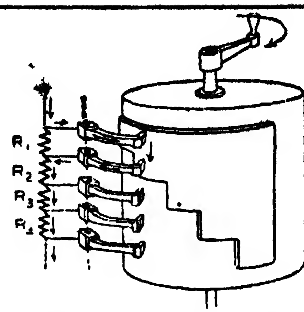
143. MOTOR: OPENED, SHOWING ARMATURE AND UPPER PAIR OF MAGNET POLES

The principle on which the controller works is shown in **145**. As the handle is moved round in the direction indicated, the metal contact wipers come into contact with the serrated copper plate upon the controller drum, and in this way the successive alterations in the connections are made. Fig. **148** is a developed diagram to show the operation of switching the motors in series and parallel. When the controller is in the *series positions* the current flows through GI, *a*, H, and J, and the motors are thus in series; and when in the *parallel positions* the current divides at G and flows in the following manner:

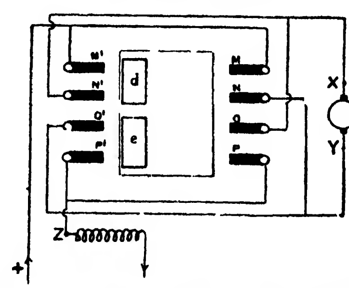
$$G <^{b\,H}_{I\,c}> J.$$



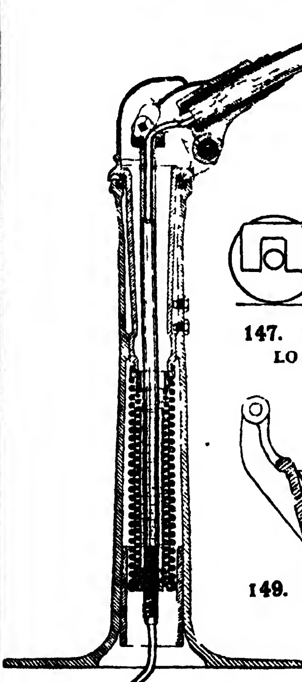
144. DIAGRAM OF STAGES OF CONTROL



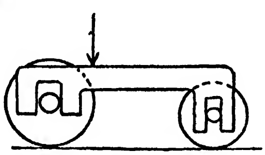
145. PRINCIPLE OF CONTROLLER DRUM



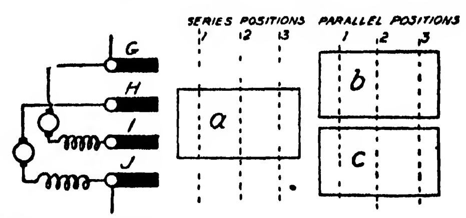
146. DIAGRAM OF REVERSING DRUM



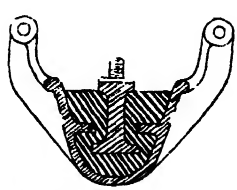
151. STANDARD FOR TROLLEY-POLE



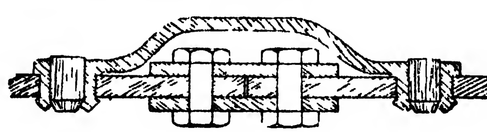
147. DISTRIBUTION OF LOAD ON TRUCK



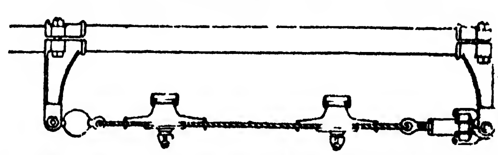
148. ARRANGEMENTS FOR SERIES AND PARALLEL



149. INSULATOR FOR CURVES

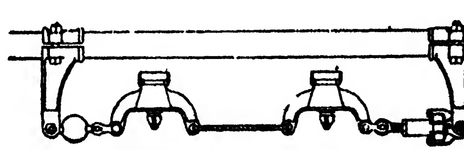


150. BOND BETWEEN RAILS OF TRACK



152. OVERHEAD CONSTRUCTION FOR STRAIGHT PART OF ROAD

153. INSULATOR TO TAKE STRAINS



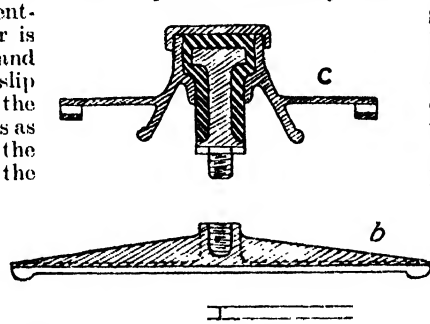
154. OVERHEAD CONSTRUCTION USED IN CURVES

144-154. MOTOR CONTROL, OVERHEAD-WIRE AND TRACK CONSTRUCTION

How the reversal of the motors is carried out is shown diagrammatically in **146**.

To reverse the direction of rotation of a motor, the field current has to be reversed with respect to the armature, and this is done by moving the drum to the left or to the right so that the metal plates A and B come into contact with the left-hand or right-hand set of wipers. In the former case the path of the current is $+M'dN'XYO'eP'Z-$, and in the latter $+MdNYXOePZ-$, so that, while the directing Z to — remains the same, the direction between X and Y is changed.

Tramway Trucks. Small cars are mounted upon single trucks with a motor mounted upon each axle of the truck. As, however, it is not practical, from the point of view of rounding curves, to have the wheel base—that is, the distance between centres of the wheels of a truck—much more than six feet, it becomes necessary to mount the larger cars upon two trucks. In the inter-urban cars much used in America, each axle is again used for driving, and four motors in all are installed, but the usual practice in England is to have only two motors, one on each truck. By this arrangement a certain percentage of the weight of the car is lost for tractive purposes, and the driving wheels will slip sooner. To get over this the car is mounted on the trucks as indicated in **147**, so that the weight is taken nearer the driving wheel than the pony wheel, and in this way from 75 to 80 per cent. of the weight of the car is used, for giving adhesion to the rail when driving.



155. DETAILS OF OVERHEAD SUSPENSION

Brakes. The safety of a car depends upon the reliability of its brakes, and these should, therefore, receive the best attention. All the different forms of brakes may be divided broadly into three classes—namely, wheel brakes, track or slipper brakes, and electric brakes.

Wheel Brakes. Of the first the best-known form is where cast iron or hard wood brake shoes press against the rim of the wheels. The limit to the power of this form of brake is the adhesion of the wheels to the rail. When the brake shoes are pressed so hard against the wheel that the grip between the wheel and the rail is overcome the wheel slips, and it has been found by experiment that when the wheels start slipping they continue to slip even after the brake pressure has been considerably relieved, and that at the moment of slipping the brake action *becomes reduced to a third of the former value when the friction was all at the brake shoe.*

Slipper Brakes. In the second type of brake—namely, the track brake—a shoe is pressed down on the track, and the limit to this form is, of course, the weight of the car; for any downward pressure on the rails is counteracted by the upward force which tends to lift the car off the rails, or, if not altogether to lift it, to relieve the wheels of a portion of the weight of the car and so make their running less certain. This objection is, however, got over by making an electromagnet of the brake shoe and producing the necessary pressure by the magnetic attraction between the iron shoe and the steel rail.

Electric Brakes. The third form of brake is that in which the motors are made to act as generators, and the energy they produce as such is of course taken from the moving car, with the result that it is retarded. The generated current is often passed through resistances, as described above, but it may be used to excite the magnets in the slipper type of brake. The Westinghouse Company have sold very large numbers of a brake in which the motors are made to act as generators and the current so derived is sent round the coils of the slipper brake. The attraction of this to the rails also actuates the wheel brakes, so that all three types of brakes are instantly applied by a movement of the controller handle.

The Return Circuit. To provide an efficient return path for the current after it leaves the tramway-cars is an important matter. In telegraphy the currents are allowed to return for hundreds of miles through the earth, for here the currents are small. With electric cars, it was found that, with the large currents used, neighbouring gas and water pipes became damaged. With a view to protecting these pipes the Board of Trade have made rules, the most important of which is that on no one part of the return circuit shall there be at any time more than seven volts above the negative terminal of the generator. To ensure that this is so, among other things, the separate lengths of rail which form the track must be connected together electrically. The means used for mechanical fastening are not sufficient for the electrical purpose, so that special arrangements have to be adopted to accomplish it.

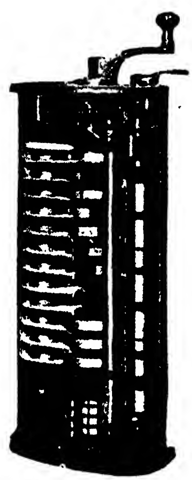
In some systems, the lengths of rail are welded to one another, but the usual way is to bond the rails with thick copper connectors which are firmly riveted into adjoining rails. Fig. **150** shows a well-known type of bond. Holes are drilled into the web of the rail, and they must be thoroughly cleaned before they receive the shank of the bond. When this has been fixed firmly in place, a hard steel stud is then forced into the hole down the centre of the shank, with the result that the bond and the rail are forced into very intimate contact. It is found that by far the greater part of the resistance of the bond is in the contact between it and the rail, so that the greatest care must be taken to see that the rivet is right home. As a further precaution the various track rails are cross-bonded at intervals.

Overhead Construction. The problem in overhead construction may be stated thus: *Suspend a copper wire, of diameter about ⅓ of an inch, over a tramway track in such a way that great mechanical strength is obtained, with an insulation sufficient to withstand* 500 *volts.* As regards the poles, three methods of construction are used in England—namely, (1) a side-pole on one side of the road with a long bracket which supports both the up and the down wire; (2) a centre-pole along the middle of the road, with short brackets on each side; and (3) poles on both sides of the road, the conducting wire of copper being slung from a steel suspending wire stretched across the road. The second makes the best mechanical job, but is bad in busy streets. The first is cheaper than the third in other cases where the width of the road would not necessitate an extra long bracket. The wires themselves [**155***a*] are supported by soldering their ends into what are known as *ears* [**155***b*], which are screwed into *insulators*, such as **155c** and **149**. The whole arrangement is then slung as shown in **152** and **154**; a second insulator, as **153**, being inserted before the suspension is made fast to the pole. The constructions shown in **152** and **154** are adopted for the first method of suspension mentioned above, **152** showing the arrangements on straight runs of line, while **154** is the arrangement which is used on curves, where the wire must be on the same level as the tackle which takes the side thrust from the trolley-pole.

Construction of Insulators. The material generally used for tramway insulators is brittle, and, in consequence, cannot withstand any great tensile stress, although it is strong against compression. In consequence of this the insulators have to be so constructed that the pull between the ends is taken up in the insulator by a compression. How this is done may be easily seen by tracing out the path of the stress in the section shown in **153**, and also in **155c** and **149**. The insulation resistance of an exposed insulator depends upon two things—namely, the material of which it is made, and the state of its surface to prevent creeping of the current along any film of moisture that may form. The section in **153** has been specially chosen to meet this last point, for the rain falling on it will not drain off on to the metal eye-pieces at the end, but will flow to the projecting rib which passes around the centre. Porcelain insulators are being used to an increasing extent in overhead tramway construction.

Special Details. For crossings, special ears, knows as *frogs*, have to be provided to guide the trolley on to the required line. Other special requirements are when the line runs from one section to the next, each section being supplied with its current separately. For this a larger ear is used, made in two parts, insulated from one another and from the common support. Many types of frogs and section insulators are used.

Collecting Trolley. The means almost universally adopted in England and America for collecting the current from the line is by a trolley. A trolley is a grooved wheel mounted on the end of a more or less flexible steel pole, which, in the case of cars with roof seats, is supported on a pillar about six feet high. A section showing the inside mechanism of a usual type of pillar is seen in **151**. The arrangements provide for the movement of the trolley-pole up and down to suit the varying heights of the overhead wire, for supplying an upward pressure to the pole, so that the trolley-wheel makes a sure contact with the wire, and for swinging the pole round when the direction of motion of the car is changed. Such a collecting trolley is usually fitted to a swivelling head, which allows itself to follow the position of the trolley wire even if this is not over the centre of the track.



156. TRAMWAY CONTROLLER
By courtesy of Messrs Dick Kerr & Co.

Surface-contact and Slot-conduit Systems. Many attempts have been made to do away with the overhead work in electric tramways. These efforts may be divided into two classes: one in which the current is conveyed to the car from studs set in insulating blocks of cement or asphalt in the surface of the road, and the other when the current is collected from conductors buried in a conduit, access to which is obtained through a slot.

In surface-contact systems the studs are placed about six feet apart; and when no car is passing over them they are automatically disconnected from the circuit and become dead. The car passing over the studs connects them to the feeding circuit. In some cases the switch to do this is actuated mechanically by the weight of the car, but more frequently this is done by electromagnetic means. In some systems a long electromagnet fixed under the car acts magnetically on an armature in a sunken box under the stud. In others, the electromagnet that moves the switch is placed in the stud-box, and is brought into operation by the car making electric contact with the stud. In all cases the car is provided with a long metal skate or runner under the car, which glides from stud to stud and so continuously picks up the current from the mains through the studs.

In the conduit system the live conductors are placed on insulated supports in a tunnel or conduit which runs along under the middle of the track. The conduit has a slot about one inch wide opening all along into the road, and through this slot is let down from the car a *plough*, which collects the current. It is an easy matter to mount two conductors in the conduit, one on each side of the slot, and so provide an insulated return for the currents, so that the bonding of the rails becomes unnecessary.

SILVANUS P. THOMPSON

Influence of the Different Schools. Sight Reading. Pianoforte Study in England. Examinations. Memorising, Teaching, and Performing.

PIANOFORTE PRACTICE

ALTHOUGH the pianoforte is a comparatively modern instrument, and had not yet ousted the harpsichord by the end of the eighteenth century, still, the keyboard music of the Elizabethan period (1600), when English harpsichord players and composers were the first in Europe, is adaptable to the modern instrument. The music of the French Couperin of a century later (1700) is a rich storehouse of dainty keyboard pieces, while his contemporaries, the Italian Scarlatti and the German Bach, are used at this day as pianoforte classics.

Grading our Teaching Material. In grading music, moreover, for *teaching* purposes we do not take it chronologically. On the contrary, we should start with the music that is easily understood at the present day, and gradually learn to appreciate the idiom of the more difficult, because more remote, classics. And here, again, it is wise to begin with the music of Clementi, who lived a century later (1800) than Couperin. Clementi's music helps to form good keyboard habits, lying easily as it does to the hand, and affording a rich supply of pleasant material for the practice of scale passages and broken chords and the like, and containing nothing eccentric. It is not, however, very exhilarating musically, and the young student must have this sort of fare interlarded with bits from the modern romantic school—Schumann's "Jugend Album," Tschaikowsky's "Jugend Album," Grieg's "Lyric Pieces," Jensen's "Wanderbilder," and the like. Easy duet playing should be begun as soon as possible, and if Mrs. Curwen's method be used for beginners—which can be highly recommended—the elementary duets in it will be found to open an easy door to the delightful world of "ensemble" playing. The study of the really great masters of pianoforte literature—Bach, Chopin, and Beethoven—must not be entered on too soon; Schumann's bigger works, his "Papillons," "Novelettes," "Fantasie-stücke," etc., should also be left to a fairly advanced stage. His music, on the whole—like that of Brahms—is not so well calculated to lead the player into good tone production as Chopin's, although there are some works that prove the exception—for special purposes.

Influence of Chopin. Chopin's influence on the player's technique is like that of Bellini's on the singer's. These both insensibly lead the student into the "bel canto" with its exquisite beauty of tone and phrasing. One may say that, as a rule, the student should study the beautiful before the characteristic.

Mendelssohn's "Songs without Words" are dainty little tone pictures suitable to lead up to more solid fare, and a useful graded edition of them is Germer's, where you will find them in the order of difficulty. Easy and graceful salon music, such as Durand's waltzes and Godard's, Schuloff's, and Chaminade's pieces, should not be neglected, especially in the pianist's early stages, as they are suggestive as to colouring, rhythm, etc. Neither should waltzes be tabooed, as they teach much in a simple way in the matter of good phrasing and good melody work, and, again, rhythmical feeling. An excellent introduction to Chopin's Nocturnes will be found in some of Field's; and the knowledge of the fact that the French Pole began his nocturne writing in imitation of the Irish pianist composer makes the comparative study of the two interesting.

Introduction to Study of Bach. The best introduction to Bach is Bach. Use his little preludes and his two-part and three-part "Inventions" sandwiched with the easy gavottes, etc., from the suites; but the study of Bach should be preceded by a good course of Scarlatti. As we have said, in the earlier stages use the lighter works of the classical school—some of Kuhlau's sonatinas can be recommended—but do not omit to couple these with short romantic pieces.

Beethoven stands as the dividing line between the purely classical and the ultra-romantic schools. The great classicists before him were Haydn and Mozart; the great romanticists after him were Schumann, Chopin, and Liszt. The latter almost completely changed the style of pianoforte playing, but they themselves were grounded in the older classical school. Liszt, the greatest pianist of the nineteenth century, was a direct pupil of Czerny, whose pupils we all are, in an indirect way, through the practice of his famous studies.

It is reported, by the way, that the master wrote these studies standing at a desk in his teaching-room, while his pupils played through what they had prepared for their lessons.

Guides to Teaching Material. As a guide to the choice of teaching material of all kinds, one should possess such a book as Eschmann-Dumur's "Guide du Jeune Pianiste," which is a catalogue of the entire repertoire of pianoforte pieces and studies graded from the earliest stages up to the virtuoso summit.

For the application of educational principles to the elementary teaching of music there is Mrs. Curwen's Teacher's Guide, in two grades, and for helps in teaching the elements of form and elucidating the emotional content one should consult such books as Carpé's "Phrasing" (Novello), Ridley Prentice's "The Musician" (a guide for pianoforte students in six grades), Knott's "Elements of Music," and Corder's "New Morley." If we buy our music (the

standard works) as far as possible in volumes, we may thus form a library. The classics are cheap. Mendelssohn's *complete* pianoforte works, for instance, can be had in a beautiful edition for 7s. 6d. A complete copy of Chopin's mazurkas, the very best edition—Bote and Bock—can be had for 2s., and so with all his works. Beethoven, Schubert, Schumann, can be had on like terms. But it is a mistake to buy *miniature* editions for *study*, as they are bad for the eyes, and hinder ease in playing.

Sight Reading. As we advance we must patiently work at sight reading. In the elementary stages we may use Kunz's "Canons" (five-finger exercises in all keys), which can be used later as material for the practice of transpositions. With a fellow enthusiast let us play four-hand arrangements, beginning with easy gavottes by Rameau, Lully, etc., and persevere till we can play the symphonies of Haydn, Mozart, Schubert, Beethoven, and Schumann.

Nothing is so good for sharpening our rhythmical sense, and for acquiring and keeping up the art of sight reading, as ensemble playing of any kind. We should play accompaniments to violinists and singers whenever we have the chance. Begin with easy things. The good accompanist is rare. Schumann said that accompanying was a test of the musician. Transposition, which has already been treated in the SELF-EDUCATOR [see page 1013], should be studied, and for practising material we might get "Warriner's Transposition." In addition to the sight reading of song accompaniments we should *study* the best of the art songs, and ask the co-operation of singers. Such songs should not be approached merely from the singer's point of view—pianists will learn much from them.

The Modern Composers. There yet remains to be mentioned the pianoforte music of the latter half of the nineteenth century—that of the German Brahms, of the Scottish-Norwegian Grieg, of the Bohemian Dvorak (whose original four-hand music, "Legenden" and "Slavonic Dances," is of great value), of the Russians, Rubinstein, Tschaikowsky, Glazounow, Arensky, Rachmaninoff, Blumenfeld, Scriabine, Liadoff, and others; and that of the Parisian School—Saint-Saëns, César Franck, Debussy, Ravel, Mozkowski, Chaminade, etc., of the Scottish-American Edward Macdowell, whose "American Wood Idylls," "Sea Pieces," "Indian Idylls," and the like, are charming tone sketches of a light nature. The British composers since Sterndale Bennett, whose "Lake," "Millstream," and "Fountain" are alike poetic and pianistic, although they have occasionally written for the piano, have yet occupied themselves chiefly with cantatas, operas, and orchestral work, although mention must be made of Sir Alexander Mackenzie's fine pianoforte concerto, the "Scottish," a work of really high rank. The younger British composers are, however, writing extensively for the piano, and among them there is not only great promise for the immediate future, but already brilliant achievement, as shown, for example, in the works of York Bowen, Percy Grainger, Balfour Gardiner, Thomas E. Dunhill, and Benjamin Dale.

Teaching. A few words now about teachers and teaching. Much is required from the pianoforte teacher. He is expected to teach alike literature and public speaking, as it were; he not only reads the classics with us, but trains us as dramatic reciters. Some teachers are strong on one side, some on the other, and some few are famed for both. Some try to make of the pupil a sound musician, some specialise in training for brilliance, some try to give technique, some interpretation. The art of tone production, or touch, till recent times, was left largely to chance. The most far-famed teacher in Europe for the last thirty years has been the Pole Leschetitzky, in Vienna. He is an old man and much in request; it is not easy to get lessons from him; but he has a great number of "preparers" who work with him, giving two or three lessons a week. Busoni is also among the greatest of living teachers. Great artists—performers such as D'Albert, Paderewski, and others—sometimes give occasional lessons to artist pupils, but one goes to them for hints on style and interpretation, not for technical and systematic instruction. The Continental conservatoires are inexpensive—some of them, indeed, free—but although the small towns in which they are located offer advantages in the form of a musical atmosphere for the young student, the pianoforte teaching in some of them is based on out-of-date "Methods," and the lessons given are of little more than merely nominal duration; so that the student finds it necessary in many cases to pay for additional private lessons outside the institution.

Pianoforte Study in England. But, except for a perhaps cheaper and brighter life, there is no need for the ambitious pianoforte student to leave our own country; and, indeed, except for the sake of gaining a wider and more varied experience at the end of his student days, before settling down to a teaching or performing career, it is foolish of him to leave our shores, since our own schools and private teachers are really far stronger than the Continental piano teachers at present. The student must *hear* a great deal of good music; it is one of the most important factors in his education. Much good music can be heard in London and the provinces, orchestral, solo, instrumental, and vocal; and all the great performers visit us periodically. The pianoforte student must not neglect opera either, since much pianoforte music, many of Beethoven's sonatas and Chopin's compositions, for example, pre-suppose an acquaintance with dramatic diction, so to speak. The Royal Academy and the Royal College of Music can offer an all-round musical education second to none in Europe. For pianoforte playing we can nowhere get more satisfaction, more fruitful teaching, than at the Royal Academy, of which one of the professors has sent out the most complete and

scientific monograph on pianoforte touch and technique (in its widest sense) that Europe or America has yet seen. We mean the author of "The Act of Touch," etc., so often quoted in these pages, Tobias Matthay, a London-born German, whose interpretative teaching is as striking as his technical in its results. Students may enter the Royal Academy for one year, but three years is understood to be a course. They may enter at any time, although the academic year begins in September. Fees are thirty-three guineas per annum. Alike at the Royal Academy and at the Royal College, there are a great number of scholarships which can be obtained by those sufficiently talented at competitions, the dates of which are duly announced. And, of course, private lessons may be obtained of all the teachers of these institutions, if the student does not wish to join one of these.

Examinations. The professional certificates obtainable are those of the R.A.M., the Metropolitan Examinations (Licentiate), held in September and at Christmas, and those of the R.C.M. (Associateship), held at Easter. It is now quite expected that young professional musicians should pass one of these examinations, and it is difficult to obtain positions at schools without them. These examinations are held in London only, at the institutions themselves, but for the purpose of holding examinations in the country the two institutions combine, under the title of the Associated Board, and examinations in pianoforte playing are held by it in the provinces, at local centres. Although these examinations are not, strictly speaking, professional examinations, they are held in repute by musicians all over the country.

As to the preparation for examinations, even if one feels oneself fit for the work, it is safer not to hurry. We should take two years, preparing the prescribed work for both. When the stuff comes out *study* it carefully, make it our own, then lay it aside a little and take it up again to polish. Von Bülow said "there never was a piece composed yet that had no difficulties." Select difficult passages and work at them quietly and steadily; know them intimately on the keyboard and go over them always with concentrated attention. Then gradually work them in with the preceding and following bars until they are securely built into the edifice. Then beware, for although practice means that we are getting our fingers to find their keys semi-automatically, yet *we must never* let our playing get entirely automatic; it then gets dead and goes from bad to worse. We must keep the rhythm *alive*, *will* it every time we play, and quick movements will not then run away with us; we shall have them in rein.

Necessity for Regular Practice. Many students who succeed in playing a toccato-like movement fairly well at first, practise it into everything that is bad just because they do not attend to what they are playing, neither musically nor technically, and so the rhythmical grip is lost, and nothing then avails but to put the piece aside until such time as the mind can take it up afresh and give the needful vivid attention.

To gain endurance we must practise regularly, but with breaks; it is not wise to play more than two hours consecutively, and not even as long as this until we are well in training. Frequent quarters of an hour of tiring technical work suffice; rest brain and nerve and muscle, then return to work. Begin as early in the day as possible, and take frequent intervals for healthy outdoor exercise. The amount of practice will count for nothing unless it is *every day* begun well and kept on the right lines. We should begin with, and have frequent recourse to, the Daily Tests, quoted from Matthay's "Act of Touch" and "Relaxation Study."

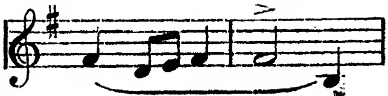
The Student's Piano. Secure as good a piano as possible; it is one of our best teachers, because of the wonderful variety of tone obtainable from it. It tempts one to paint with tone. Have a grand if possible. If we can afford only an upright (a cottage), we must get the best maker we can afford; and if we cannot buy outright, all the good makers offer the three years' system, which is better than hiring. The best makers are Bechstein, Steinway, Broadwood, Erard, and Blüthner, and some of the younger English firms are also rising in public estimation.

Performing and Memorising. Lastly, about performance. If we are amateurs we should try to play simple things to perfection, and should not attempt to perform to others things that present real difficulties to ourselves. Needless to say, we must memorise one or two short lyrics and keep them polished up ready for use. It will help greatly to memorise if we first *analyse*. Let us try it, say, for Grieg's "Elfin Dance" from his first book of "Lyric Pieces." The simplicity of the material and frequent repetitions make it comparatively easy. It is in the key of E minor, and the first five chords—all of them the chord of E minor save one—give the rhythmical germ of the whole. Note the deviation at the third chord from B and E by contrary motion to C, printed in small type.

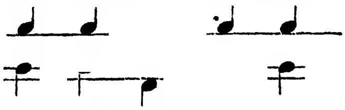
The following passage is again made out of the E minor chord, this time it is embroidered with passing notes:

Learn each of these little bits carefully and join them together. We shall not proceed further till we have absolutely mastered these two and their connection one with another. Next follows a repetition of the opening chord motive, this time on B minor; add this to the other two.

Then note specially, in what follows, the little fairy horn motive for the left hand.

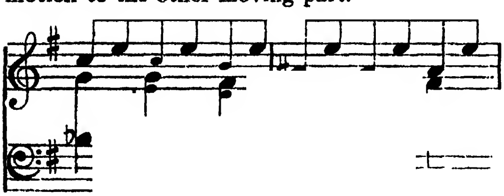


This requires very careful study and practice, and we must always *attend* to it, hearing the horns mentally before playing the passage, and listening to make sure that the horn passage really tells through the upper accompaniment. And now the whole thing is repeated. Then comes again the five-beat motive, very easy to remember this time, for it is in single notes, forming octaves between the two hands.



In the next passage observe that there are two persistently recurring notes, A♯ in the right hand and C♯ in the left, while the *moving* notes E, F, G, and G, F, E, are just the reverse each of the other.

This fairy-tripping measure, after a repetition of the five elephantine footsteps, is again heard, although in the notation picture the A♯ appears now as B♭. Then follows an exact *imitation* of this a minor third higher, and still another and a higher, but this time not an *exact* imitation, for the bass here moves in *similar*, not contrary, motion to the other moving part.

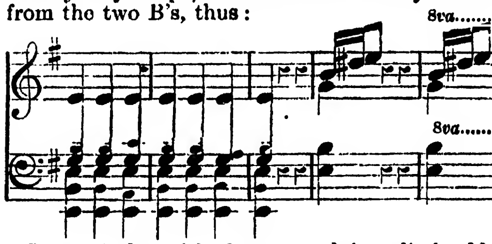


The second of this pair of bars is re-echoed in the two bars that follow, the only fresh idea being the suspension of the E over the D♯, thus:

And now all is repetition *da capo*, till we reach the last line, the coda, the tail-piece, which enters suddenly after the latter part of our second motive, imitating and re-echoing it thus "with a dying fall":

Chord A.

This re-echoing is based upon a series of chords, each introduced by a passing note half a tone below a note of the chord—these passing notes are printed in smaller type. Now we close with the opening chord motive, lengthened by two additional throbs, and note here again how simply variety in unity has been obtained—unity and variety have been said to be the keys to beauty—by simple deviations in contrary motion from the two B's, thus:



It concludes with these two dainty little elfin screeches on the chord of E minor with expressive interloping half-tone-below passing notes—D♯.

If we have never memorised before, we should try this, taking it quietly, perseveringly, intelligently, imaginatively, and—provided we do not let the mind wander—success is sure.

Nervousness. Most artists suffer from nervousness. If we could think more of composer and composition and less of ourselves we might get rid of it. As Matthay has pointed out, if only you succeed in really listening while you play, and realise that your audience is listening also to the *music*, and therefore not to you personally, that moment all nervousness disappears as if by magic. Practising clubs are useful. As members we may learn to play before others, which we should take every opportunity of doing. The key resistance varies on different instruments. It is well to be able to prelude that we may test this resistance sufficiently on a strange piano before beginning serious performance. We should practise preluding on series of chords and dare to improvise. If we persevere in this as in all else, what is exceedingly difficult to do at first becomes automatically easy in course of time, till we forget that we ever had to learn.

M. KENNEDY-FRASER

A SHORT DICTIONARY OF TERMS IN MUSIC

ABENDLIED—An evening song.
Accelerando—More and more quickly.
Acciaccatura—A short grace note (see text).
Adagio—Leisurely, deliberately.
Ad Libitum — At the performer's pleasure as to time.
Agitato—In an agitated style.
Alla Breve—The time with two minims in a bar; seldom used in modern music.
Alla Cappella—In the church style.
Alla Marcia—In march style.
Allegretto—Light and cheerful; not so fast as *Allegro*.
Allegro—Lively, briskly; in a gay and merry way.
Allemande—A German dance tune in triple time.
Al Segno—To the sign (see text).
Alt—All notes in the octave above G in top space of treble-clef are said to be *in alt*.
Amore, Con—With tenderness.
Andante — Literally, going, walking; going easily, fluently, moving on.
Andantino—Slower than *Andante*.
Animato—Animated, usually as to speed.
Anthem — A sacred composition for voices, words usually Scriptural.
Appassionato—Impassioned, with feeling.
Appoggiatura—A grace note (see text).
Arpeggio—Notes of a chord played in succession (see text).
Assai—Very, as *Allegro assai*, very quick.
A tempo—In time.
Attacca—Attack; without pausing.
Aubade—A morning song.

BAGATELLE—A trifle; a short easy piece.
Barcarolle—A song or composition in imitation of the Venetian gondoliers.
Ben—Well; as *Ben Marcato*, well marked.
Berceuse—A cradle song, a lullaby.
Bis—Twice (see Text).
Bolero—A Spanish dance in triple time.
Bourrée—An old French dance in triple time.

CADENZA—An ornamental passage, often improvised at the close of a composition.
Calando—Literally, falling away; gradually softer and slower.
Canon—A composition in two or more parts in which the parts continually imitate each other.
Cantabile—In a singing, melodious style.
Cantata—A choral composition of several movements, with solos, &c.
Canzonet—A piece, vocal or instrumental, of a flowing character.
Capriccioso—Capriciously, as to time.
Catch—A humorous vocal piece for several voices.
Cavatina—A graceful, simple air.
Coda—Tail; the end.
Con—With. *Con Amore*—With affection, lovingly. *Con Anima*—With soul, in a feeling manner. *Con Brio*—With animation. *Con Fuoco*—With fire. *Con Espressione*—With Expression. *Con Moto*—With movement. *Con Spirito*—With spirit. *Con Sordini* With dampers (piano); *i.e.* without pedal.
Crescendo—Gradually louder.

DA CAPO (D.C.) —From the beginning.
Decrescendo—Gradually softer.
Diminuendo—Decreasing as to tone.
Dolce—Sweetly, gently.
Doloroso—Dolorously, with an expression of pain.
Due Corde—Literally, two strings. The soft pedal (piano) to be released.

ENHARMONIC—Similar in pitch, but differing in name, as G♯ and A♭.
Ensemble—Together; *ensemble* playing, concerted playing.
Espressivo—Expressively.
Etude—A study; an exercise.
Extemporise—To create music on the inspiration of the moment.

FALSETTO—Head or feigned voice as opposed to natural or chest voice.
Fanfare—A trumpet tune; a flourish of trumpets.
Fantasia—A composition in free, fanciful style.
Fine—The end; used after a repeat (see text).
Forte, Fortissimo (*f*, *ff*)—Loud; very loud.
Forza, Con—With force.
Fugue—A composition in which parts do not all begin at once, but, as it were, follow each other successively.

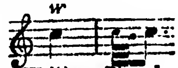
GAMUT—Old term for the scale.
Gavotte—A lively dance of French origin, popular in seventeenth and eighteenth centuries.
Giocoso—Humorously, jocosely.
Gioioso—Joyous, cheerful.
Giusto—Just, strict, as *Tempo Giusto*, in strict time.
Glee—A composition for voices, peculiar to England.
Glissando—The playing of several rapid scale notes successively, by sliding one finger along the white keys of the piano, instead of separately fingering each note.
Gondolied—A gondolier song.
Grandioso—Grandly.
Grave—Gravely, solemnly.
Grazioso, Con grazia—Gracefully.

HORNPIPE—An old English dance.

IMITATION—A species of fugue where the parts imitate each other.
Impetuoso—Impetuously.
Impromptu — Extempore, unpremeditated; a piece like an improvisation.
Intermezzo — Literally, intermediate; introduced between acts of an opera, &c.
Introit—A short anthem preceding the service of the Roman Catholic Church.

LANGSAM—Slowly.
Larghetto—Rather slow, in a broad style.
Largo—Slow and solemn.
Legato—Smooth, connected.
Leggiere—Easily, lightly, delicately.
Lento—Slow.
Lied—German term for a simple song.
L'istesso tempo—The same time; used where a change of time-signature occurs, to indicate that the length of the beat remains the same though represented by a different kind of note.
Loco—The place: after *8va*, to point out that the music is to be rendered in its proper octave, as written.

MA—But; as *Vivace ma non troppo*, lively, but not too much so.
Madrigal—An unaccompanied part song
Maestoso—With majesty or dignity.
Mano Destra (M.D.)—The right hand. *Mano Sinistra (M.S.)*, the left hand.
Marcato—Marked, emphatic.
Marziale—In martial style.
Mazurka—A Polish dance, in triple time.
Meno—Less, as *Meno allegro*, less lively.
Mezzo—Medium, as *Mezzo forte*, moderately loud.
Minuet—An old French dance, in triple time.
Moderato—Moderate, as to pace.
Molto—Much, very, as *Molto allegro*, very lively.
Mordente—A little note before a principal note to give it point, as thus—



Written. Played.

Morendo — Dying away; gradually diminishing the tone.
Mosso—Moved, as *Più mosso*, more moved, quicker.
Moto—Movement, motion (see *Con moto*).

NOCTURNE—A composition of light and elegant character.
Non—Not; *Non troppo*, not too much.

OBBLIGATO—Indispensable; a part or accompaniment of essential importance.
Octet—A composition for eight instruments or voices.
Op. (for **Opus** or **Opera**)—A work; used to indicate the number of a composition in the order of its composer's works.

PASTORAL—A simple air, in $\frac{6}{8}$ time, of a rustic character.
Ped.—The sustaining, usually called the loud, pedal of the piano.
Perdendosi—Losing in sound, growing softer.
Pesante—Heavily, impressively.
Piano (*p*)—Softly.—**Pianissimo** (*pp*)—Very softly.
Più—More, as *Più allegro*, more lively.
Plainsong—The most ancient kind of ecclesiastical music.
Poco—A little, as *Poco a poco*, little by little.
Polonaise—The Polish national dance, in triple time.
Pomposo—Pompously.
Portamento—Gliding from note to note in singing.
Presto—Fast. **Prestissimo**—Very fast.

QUASI—Like, in the style of, as *Andante quasi allegretto*, Andante in the style of allegretto.
Quintet—A composition in five parts.

RALLENTANDO—Gradually slower.
Recitative—Musical declamation.
Rhapsody—A composition in a free style.
Risoluto—In a resolute manner.
Ritardando, Ritenuto—Retarding the speed.
Rubato—Literally, robbed: *Tempo Rubato*, a slight deviation to give more expression by retarding at one place and quickening at another; not in strict time.

SCHERZANDO—Playfully.
Scherzo—A lively, playful piece.
Sempre—Always, as *Sempre staccato* always staccato.
Senza—Without.
Senza Sordini—Without dampers (piano), *i.e.* with pedal.
Sforzando, Sforzato (Sf.)—Forced, with great emphasis.
Smorzando—Gradually fading away.
Sostenuto—Sustained.
Sotto Voce—In a subdued tone.
Staccato—Short, detached (see text).
Stringendo—Hurrying on the speed.
Syncopation—Irregular or cross accents; binding the last note of a bar to the first note of the next; accented notes occurring in the unaccented part of a bar (see text: *Counterpoint*).

TARANTELLA—A Neapolitan dance in $\frac{6}{8}$ time.
Tempo — Time. *Tempo Primo* — the original pace (after Rallentando, etc.).
Tenuto (Ten.)—Hold for the full time.
Tremolo—Trembling; the rapid alternation of notes to produce a trembling effect.

UNA CORDA—One string; *i.e.* with the soft pedal.

VELOCE—Rapidly, swiftly.
Vibrato—With much vibration of tone.
Vivace—Lively, vivacious.
Volti Subito (V.S.)—Turn over quickly.

The Processes which Cotton Yarn Undergoes. Doubling. Making Fancy Yarns. Conditioning.

TREATMENT OF COTTON YARN

The work of the cotton-spinner proper ends with the production of yarn of single strand. The yarn is a complete article fit for weaving, and most of it is woven in the single state. However, *single* yarn is not the best for all purposes, and so, with a view to increasing the strength and elasticity, much of it is *doubled*, or made into a compound thread of two strands or more. Doubling is carried on in some mills as an adjunct to spinning, but it is largely a separate trade conducted by doublers, who work at a fixed commission per pound of yarn, paid by the owners of the material; or by others who buy singles in the open market as principals, and sell the doubled product to consumers in the weaving, knitting, lace-making, and other trades.

We have seen that in spinning two operations are carried on upon one machine. The slackly twisted roving is *drafted* down to a finer diameter and a tighter twist is imparted to the yarn. The twist inserted in spinning is counted in turns per inch, and more turns are given to *twist*, or warp yarn, than to weft. In doubling these single yarns there is no question of drafting. The operation aims only at combining two or more threads into one with such a number of turns per inch as may be demanded by the purpose in view. The machines used resemble those used for spinning, and may be regarded as spinning-machines destitute of drafting rollers.

The Twiner. The *twiner*, an intermittent machine used principally to produce a full and elastic form of two-fold yarn, is the brother of the mule. It is fed not with rovings contained on bobbins, but with yarn spun upon mule *cops*, or ring bobbins. Two types of twiner are in common use, and that most generally employed is known as *English*. In this machine the twisting spindles are set upon a stationary frame, and the creel containing the single yarn runs to and from this rail. The place of the drafting rollers is occupied by a device which opens to allow yarn to be unwound while the carriage is running outward, and closes to prevent unwinding when the carriage is on the inward run and the spindles are putting in the twist. The faller and counter-faller wires for taking up the slack and guiding the yarn to the spindle are the same as those of the spinning-mule.

In what is called the *French* twiner the creel rests stationary, and the spindles travel outward, the details otherwise remaining the same. In either case the effect is first to draw out straight the two threads or more that are to be compounded together, and then to supply the requisite twist. Each twiner carries a large array of spindles, the number being regulated by the amount of floor-space that is available for the machine.

Ring Doubling-Frame. Doubling is also done upon continuous machines, and most largely upon the *ring doubling-frame* [1]. The bobbins of single yarn are mounted upon skewers set either horizontally or vertically above the rollers and spindles. The threads to be doubled together are led through one pair of delivery rollers, and, after passing around guides, are wound together upon an upright spindle. The spindles are enclosed by flanged steel rings set within a rail, and around this ring slides the traveller. Doubling travellers are not the C-shaped pieces of wire used in spinning, but are ear-shaped. In doubling thick yarns heavier travellers are used than in dealing with light ones, and their function is to exert a light drag, sufficient to guide the yarn, and to ensure winding on. Like the ring spinning-frame the ring-doubler works at high speeds.

The *flyer* principle is used in doubling, and it gives results excellent from the point of view of uniformity of twist and smoothness of yarn. The flyer frame, however, is unsuited for high speeds, and its principal employment is for doubling very heavy and hard-twisted yarn.

The Process of Doubling. Doubling is done either *dry* or *wet*, the dry process providing a less smooth yarn than the wet one. Loose, unbound ends of fibre start out from the yarn in the course of its passage through the air, and the effect of passing the threads through water is to lay these protruding ends flat, and to turn out a less hairy thread.

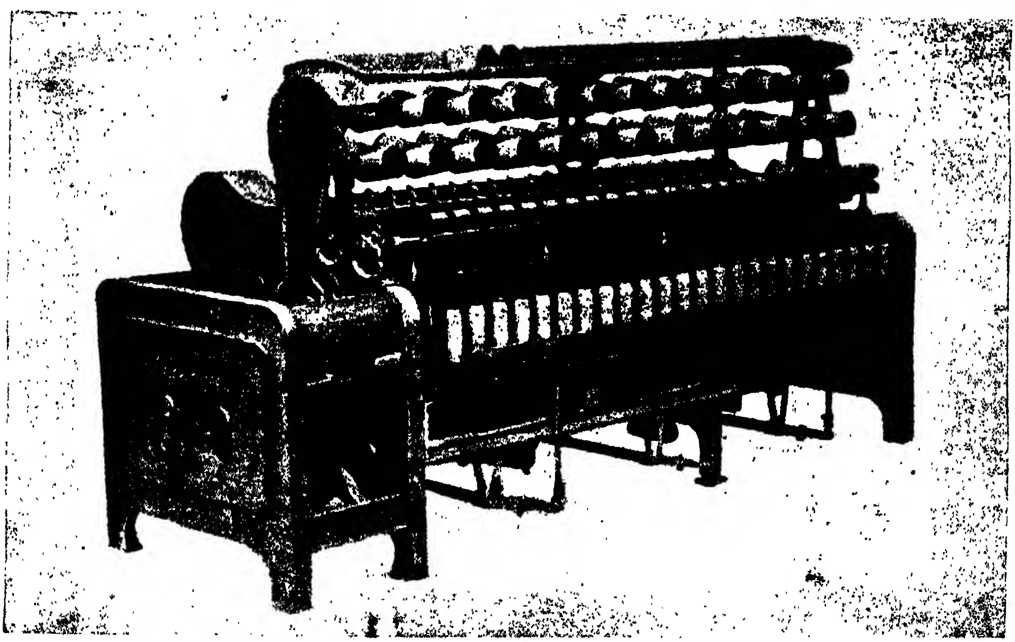
The devices for wetting the yarn in course of doubling are various. In doubling on the twiner, the singles are often steamed before being placed upon the creel; the yarn is passed through a water-trough and over a wetted, flannel-covered tension-board. In wet-doubling on the ring or flyer-frame the singles are led, in the *English* system, under a glass rod placed under water in a short trough, and from thence into the delivery rollers. In the *Scotch* system the lower of the pair of delivery rollers revolves in contact with water contained in a shallow trough, and the yarn passes beneath the lower roller, and then between the two. This method, which is used chiefly in doubling yarn to make sewing-thread, is preferred as giving a more thorough saturation.

How Faults are Avoided. Singles coming straight from the spinning-machine carry a greater or less number of imperfections. There may be untidy knots or *snarls* or *slubs*, and in doubling yarns for the more exacting purposes it is desirable to eliminate these imperfections It may be necessary also to avoid what are called *single places*, or intervals of single yarn occurring in a doubled thread. With these objects, yarn is sometimes *doubler-wound* before proceeding to

the frame that does the twisting. Ends are taken from two or more bobbins and wound upon other bobbins or tubes, where they are laid together flat and side by side with no twisting. The *clearing* of thick places is effected ordinarily by running the yarn through a slit or series of slits in a metal plate. The openings are adjustable, and are set closely enough to catch and hold any lump or clumsy knots. The obstruction is removed by the operative, a neat knot is substituted, and the process of winding is continued.

The Winder and its Work. The winders used in laying threads together in readiness for twisting lay them crosswise upon a pasteboard tube. The most common type is the *split drum* winder [2], in which the threads to be wound together are led through the diagonal cleft in a drum or cylinder. The drum is set horizontally, and head is brought to a stand in the event of the breakage of a thread. The tax on the vigilance of operatives has been considerably reduced by the general introduction of stop-motions.

Gassing the Fibre. Projecting fibres dull the lustre of yarns that are intended to look bright, and they roughen the surface of sewing-threads and impede their passage through the eye of the needle. When these projections have to be entirely removed, the yarn is *gassed* or singed by a passage through a succession of flames at such a speed that the loose fibres are burnt away, leaving the main body of the thread uninjured. Gassing may take place either before or after doubling, and in course of the winding of yarn from large bobbins on to pasteboard tubes. The flame is a mixture of gas and air, mixed under the best system in definite proportions, and



1. RING DOUBLER FOR WET OR DRY WORK
From a photograph by courtesy of Messrs. Platt Bros.

driven at the same speed as the bobbin, with the result that the yarn is distributed regularly in crosses from end to end of the tube. The simple split drum is used for coarse yarn, but owing to the irregularity of the tension at different points of the traverse the motion is not adapted for finer yarn. The defect is remedied by the insertion of a cam within the drum, and this cam in changing its position maintains a surface on which the threads can rest under uniform tension. Much ingenuity has been expended upon making winders to lay a maximum of thread in a minimum of room, and lay them in an orderly manner and at a high rate of speed without ruffling their fibres. Most of the new machines give a traverse to the thread through thread-guides of which the motion is governed by cams. One improvement has made each winding head upon the machine independent, so that only one

supplied to the burners by means of mechanical blowers. The flames may be open and set in the horizontal plane, but in the best approved type the burners are enclosed in vertical tubes. In the latter case fumes and fluff are disposed of without escape into the air of the room. The further course of the yarn depends entirely upon the use to which it is to be put; but before pursuing that side of the subject, it will be convenient to deal with some of the details of doubling and twisting.

Formulæ for Doubling and Twisting. A certain relationship between spinning twist and doubling twist is observed. There are formulæ in use by which the amount of twist is regulated. The square root of the count of the yarn is multiplied by a constant by the spinner, and this constant varies with the class of raw cotton used, and with the machine (mule or ring) and the purpose

(warp or weft). In the same way the doubler bases himself upon square root of the count of the resultant doubled yard and multiplies it, according to the circumstances, by a constant as low as 3 for soft twist, or as high as 7 for extra hard twist. In the nature of the case a very much opener twist is wanted for knitting yarn than for the tight-twisted yarn used for making lace.

The operation is spoken of as "doubling," irrespective of the number of ends that are being combined into one, but in practice it is unusual to join more than three together at one passage through the doubling-frame. When four-fold is wanted two ends of two-fold are redoubled; and in making *six-cord* for sewing-cotton three ends of two-fold or two ends of three-fold yarn are twisted into one. The operation of twisting is not always performed purely to lend strength. Single yarns of contrasting colour are often doubled together for the sake of effect, one thread, or both, having been dyed first.

Winding Yarns into Hanks. It is not impossible in these days to dye cotton yarns without unwinding them from the cop. Good results are obtained from the use of suction dyeing-machines, but it remains necessary to wind yarn into hanks for bleaching purposes. Thus, when yarn has been doubled and wound upon bobbins or upon the cross-wound tubes called *cheeses*, much has to be transformed into hanks upon the machine *reel*. The bobbins or cheeses are placed upon pegs on a shelf towards the top of the machine. The yarn is led through the eyes of guide arms and wrapped round the arms of a revolving *swift*.

The swift is a kind of skeleton wheel, with six spokes carrying rails or *ryces*, having a circumference of 54 inches. The machine is of a considerable length, to carry a large number of bobbins, and its swift, of some feet in length, is set horizontally, and its rotation wraps the yarn into hanks or large skeins. The reel is fitted with a mechanical counter, and a moving finger shows the number of revolutions upon a dial. In order to release the hanks with ease, one or more of the rails is made to fold or collapse at will. Motions are imparted to the reel so that the skeins can be diagonally wound if required, and so that the thread is distributed equally in *leas* of 120 yards. Eighty revolutions wind one lea, and seven leas (840 yards) constitute one hank. The hank having been reeled, the ends of the yarn are secured, and a *lease thread* is inserted between the leas and tied to hold the whole together.

Glazing and Knotting Yarn. Grey yarn in the hank sometimes receives a final operation, known as *preparing*, and designed to improve its lustre. The hank is hung over a pair of rollers, of which one is weighted to apply tension. The rotation of these rollers carries the hank round and round, and two other rollers are brought to bear upon the upper surface of the yarn, which is stretched and pressed simultaneously, a small amount of grease being applied to heighten the glaze.

The hanks are ready next for knotting, an operation done by slipping one end over a *hanking peg*, attached to a wall or bench, and twisting or screwing the other end by the aid of a hanking *pin*. The twisting being suitably firm, the hank is folded in the middle, and one end is tucked through to hold the knot neatly together. The knots are placed together in a bundling-piece, where they are compressed and tied with string into bundles of ten pounds each. Wrapped in paper and tied with an outer string, they are ready for packing for shipment. The number knots in a bundle denotes the count of the yarn, and in a bundle of two-fold 40s there are twenty hanks packed in neat layers. Less trouble is taken in making ready hank yarns for home consumption, which are delivered as a general rule in *long bundles*.

Trade Standards. The Manchester Yarn Contract rules, framed by representative spinners, manufacturers, and merchants, assert that a ten pound pressed bundle shall contain not less than 9 lb. 14 oz. of yarn. They lay it down also that, in the case of warps, the actual or scale weight shall not vary from the theoretical or calculation weight by more than 1 per cent. The narrowness of the margins shows with what exactitude spinners and doublers are required to work in bringing raw cotton up to the stage of finished yarn. False reeling, or, in other words, the giving of short measure by reeling in hanks of less than 840 yards, is still practised by some rivals whose competition has to be met in neutral markets by British exporters. In this country the offence is heavily punishable under the Merchandise Marks Act, and certain prosecutions undertaken in the past had a salutary effect in restraining a practice mischievous to sound trading.

Making Fancy Yarns. The class of doubling hitherto dealt with is that which aims at the manufacture of a smooth and uniformly cylindrical yarn. The object is achieved by twisting together singles of a similar size, and using machines geared harmoniously to deliver equal quantities of each to the spindles. If, by accident, too much of one component be delivered at a time, the result is a fault in the doubled yarn. But there is a minor department of *fancy* spinning which has the production of designedly irregular threads for its object. The end can be achieved, in a rough way, simply by knocking out cogs from the gear-wheels controlling the delivering rollers in a ring or flyer frame. However, *fancy twisters* are supplied with a variety of eccentric wheels and wheels with irregular cog-teeth purposely to produce irregularities rhythmically, and the effects obtained upon them vary with the materials as well as with the setting of the gears. A soft roving is sometimes twisted with a spun single thread with a view to the production of *spiral* or *slub* effects Again, similar cotton singles are doubled together to make yarn in which one thread rides upon another in a series of small loops.

Fancy yarn-making is not limited to the use of doubling machinery. Irregular yarns can be made by setting the cylinders of a carding-engine so that they roll the fibre between the two sets of wire teeth into little lumps known as *knops* or *neps*. When nepped is mixed with plain sliver the yarn contains these lumps at somewhat irregular distances, and they lend a broken surface to the cloth into which the yarn is woven. Fancy yarns are by no means always made of cotton alone, nor are they all employed in making cloths described as cottons. In many instances cotton forms no more than the binding thread, the main feature being worsted mohair, silk, artificial silk, or tinsel.

Splicing and Knotting. At the other end of the scale from the rough-surfaced fancy yarns are the so-called *knotless* yarns, used principally for making fine nets, laces, and curtains. In these goods any knot made in joining two ends of thread together appears as a blemish, and the ends have to be joined without knot. The two-fold or three-fold yarn used for these purposes is passed through the slits of a *clearer plate* in course of winding from one bobbin to another. When the yarn is stopped

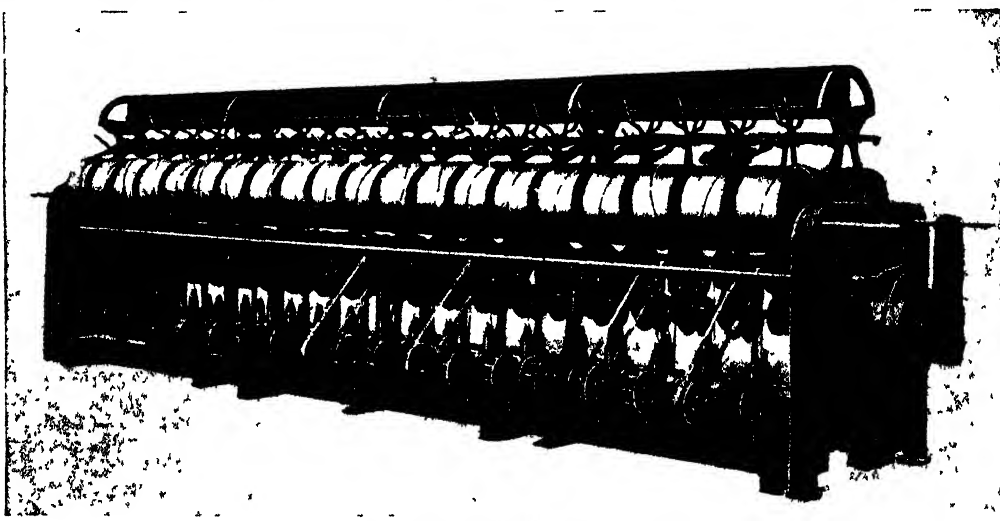
by the detection of a knot, the two bobbins are taken by the girl to a *piecing-machine* fixed on an adjacent bench. The machine has two hand-wheels, by turning which two mandrels are rotated. Slits in the end of these mandrels receive and hold the lengths of yarn that are to be spliced together, and the ends are held also by the slit in a peg set midway. The wheels are turned in the required direction to undo the doublers' twist, and when the single strands have been disengaged they are cut, brought together, and retwisted by turning the wheels to restore the twist. Skilled girl-piecers make a splice that is invisible upon inspection.

In all yarn-winding operations there are knots to be made in joining broken yarns together, and good knots can be made quickly by expert winders by hand. Bad knots, with long and unequal ends, are an exasperation, for the loose ends engage with other threads, and give trouble upon the machines. Hand knotting has been almost superseded by mechanical knotters made for wear upon the hand. In the *Barber knotter* there is an adjustable shackle, into which the palm of the left hand is introduced. The left hand is used to take hold of the bobbin containing one of the ends of yarn to be tied, and with the right hand both ends of yarn are passed over a guide forming part of the apparatus. The threads being in position, the operative simply depresses a lever with the left thumb, and thereby sets in motion sliding pieces of metal which tie a knot and trim off its ends in one operation. The process is quick, it is done without removing the bobbin from the machine, the knots are firm, close-cut, and all alike.

Conditioning Yarn. Before passing into consumption most cotton yarn receives a treatment known as *conditioning*, in course of which its weight is increased by an addition of water. The process is not to be confused with that of wet-doubling, for ordinarily the yarn loses all the water that is gained in the trough. The justification for adding artificial *condition* to cotton yarn lies in the fact that cotton is by nature hygroscopic, and absolutely dry cotton on exposure to the atmosphere takes up water from the air. Raw cotton contains moisture, and is, [illegible]ed, often watered with a hose by the cotton-[illegible]rs in America, Egypt, and India. The blowing processes, and still more the high temperature of spinning-rooms, tend to rob cotton of the moisture it originally contained, and also of the proportion of moisture that has been sanctioned by trade custom.

In correct condition 100 parts of cotton should contain 92·17 parts of bone-dry fibre and 7·83 of water; in other words, a ten-pound bundle ought to contain some 9 lb. 3¾ oz. of perfectly dry yarn. On coming from the machines yarn is not dry in the strictest sense of the word. In the experience of the Manchester Testing House, yarn fresh from the spindles has been found, when dried in an oven, to contain proportions of water varying from 3 to 7½ per cent. The object of conditioning is to bring up the proportion of moisture to the permissible limit.

Conditioning is done in various ways, and cellars for the purpose exist in most cotton-mills. An elementary method is to store the yarn upon wet bricks, or to allow it to lie overnight between wet sheets. Yarn on tight-wound cops is sometimes plunged into a tank for an instant, and then spread in cages in an airy room, to allow excess moisture to dissipate itself, and so to equalise the moisture throughout. There are ventilating and humidifying arrangements for moistening the air in the cellars in which yarn is stored before delivery. In one of these systems fresh air and steam are both blown into a long, shallow water trough, covered with a lid, in which there are diffusers to allow the vapour to spread throughout the chamber.



2. SPLIT DRUM WINDER

From a photograph by courtesy of Messrs. William Whiteley & Sons, Ltd.

Conditioning Machines. Again, there are enclosed machines in which the water vapour is carried through and over the material by the action of fans; and others in which the yarn, while lying upon wire trays, is slowly moved about in steam.

In one type of conditioning machine the yarn is fed upon a travelling apron, and led under sprays through which water is forced under pressure. The yarn is automatically turned over during its passage, and the percentage of water supplied can be varied by a change of wheels.

The process of adding condition is unobjectionable so long as it is not used to increase the weight of yarn by more than the recognised allowance.

Cotton yarn is stronger when moist than when dry, and is easier to handle. J. A. HUNTER

Identification of Minerals by Appearance, Properties, and Chemical Composition. Crystals. Classification of Minerals.

HOW TO KNOW MINERALS

We shall first consider the *minerals*, which are the chief constituents of the earth's crust, and shall then pass on to inquire how, and under what conditions, they have given birth to the *rocks* which build up the earth's surface. Two definitions may be given here, but it must be noted that they do not bear the weight of definitions in chemistry and physics.

A *mineral* is a naturally formed non-living substance which is composed of one or more chemical substances, and has certain definite physical properties by which it may at all times be recognised.

A *rock* is "a mass of matter composed of one or more simple minerals, having usually a variable chemical composition, without necessarily symmetrical external form, and ranging in cohesion from mere loose débris up to the most compact stone." (Geikie.)

Examples of familiar minerals are diamond, iron pyrites, quartz or rock-crystal, calcite or Iceland spar, common salt, mica. All constituents of the earth's crust are known as rocks, in the geological sense, when they occur in mass. Mud, sand, and loam are rocks, as are granite, lava, sandstone, limestone, and coal. We begin with an account of the chief *rock-forming* minerals, and the elements which compose them.

Chief Elements which form Minerals. The earth's crust is composed of a number of *elements*, or bodies, which cannot as yet be analysed into simpler substances [see page 842]. Most of these are found in the sun and other stars, as is obvious from the nebular theory, which presupposes a common origin for bodies which form part of our system, or, indeed, of our universe. The larger number of these elements, however, play so small a part in the constitution of the earth that they may be neglected by the elementary geologist. The following list includes the elements of which 99 per cent. of the earth's crust, as known to us, is composed, with their relative proportions, as indicated by Clarke's laborious analyses of a very large number of typical rocks:

Element	Chemical Symbol	Percentage of Earth's Crust which it forms
Oxygen	O	47·02
Silicon	Si	28·06
Aluminium	Al	8·16
Iron	Fe	4·64
Calcium	Ca	3·50
Magnesium	Mg	2·62
Sodium	Na	2·63
Potassium	K	2·32
Hydrogen	H	0·17
Carbon	C	0·12

The ten elements given above form 99·24 of the earth's solid crust.

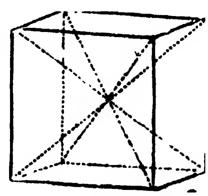
Hydrogen, of course, is of importance as one of the constituents of water, which enters largely into the composition of many rocks. *Nitrogen* (N), which forms no appreciable part of the crust, should be added to the list on account of its presence in the air. For an account of the properties of these and other elements, the reader is referred to the course on CHEMISTRY. The various minerals which we have to study in geology are compounds of these elements. About 800 of these are known, and distinguishable wherever they occur by their permanent characteristics. We need only make acquaintance here, however, with a comparatively small selection of the more common minerals. Some minerals, such as coal and the ores of the various metals which enter so largely into our industries, have a practical importance which is out of all proportion to their place in the general geological scheme, and the course of MINING deals with many which we must here be content merely to mention.

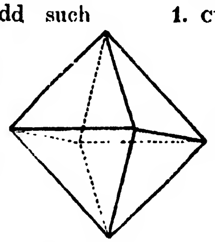
Minerals Form Rocks. All rocks are made up of one or more minerals. In the case of a rock which—as is most common—has several mineral constituents, it is necessary to distinguish between the *essential* and the *accessory* minerals. An essential mineral is one which could not be removed from the rock without materially altering its character; thus, quartz is said to be an essential constituent of all granites, whereas the crystals of topaz and beryl, which often occur in granite, are accessory—their absence would not affect the granite character of the rock. Again, we have to distinguish between *original* and *secondary* minerals. The original minerals are those which formed part of the rocks when they were first laid down, while the secondary ones have been added later, by chemical changes, or by the intrusion of water holding them in solution, or by similar methods. The veins of ore which are so important a part of the mineral resources of a country afford good examples of secondary minerals which have been introduced long after the formation of the rocks in which they occur.

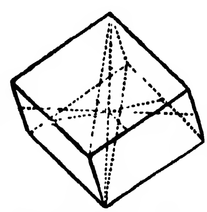
The business of the mineralogist is, in the first instance, to be able to identify any specimen which is submitted to his examination, and to state the conditions under which it is likely to be found in association with other and perhaps more valued minerals. This part of his work, as will be obvious, is of great value to the miner, but it is possible or necessary to give here only a brief outline of the principles by which it is directed. In an elementary course of geology we need concern ourselves only with a small number of the existing minerals—those, namely, which chiefly compose the more common rocks of

the earth's crust. The methods by which these minerals are identified, and their characteristics, can be learnt so simply in the laboratory and the museum that it would be a waste of time to give more than the briefest outline of them now.

How to Identify Minerals. Minerals are distinguished by (1) their external appearance, (2), their physical properties, (3) their chemical composition. Of course, the third of these tests is the most valid and satisfactory, and is always applied when the resources of a proper laboratory are at hand. But the practical geologist has to do the greater portion of his work in the field, with only the aid of such simple instruments and reagents as he can carry on his person. The prospector, who is searching for specimens of ore, is in the same position. Consequently, it is eminently necessary that he should be able to identify the more important minerals by means of the first and second tests—by their general appearance, supplemented by such physical properties as he can examine off-hand. To these he is able to add such chemical tests as can be applied by means of the simple apparatus and reagents which can be carried on a geological tour or added to the camp outfit of the prospector. By these methods the trained mineralogist can satisfactorily determine the nature of practically every specimen, though here and there he may encounter a puzzling mineral which may have to be left for thorough inspection in a properly equipped laboratory.


1. CUBE


2. OCTAHEDRON


3. RHOMBOHEDRON

There is no royal road to the power of identifying readily the more common minerals. The student must familiarise himself with their appearance by practice. He may usefully begin with one of the boxes containing fifty or a hundred typical specimens which are sold by most of the scientific instrument dealers, and then extend his researches in a wider collection of a geological museum, such as that of the Geological Survey, in Jermyn Street, the Natural History Museum, in Cromwell Road, London, or in the collections attached to any of our provincial universities. The following outline shows the main points for which to look :

External Form and Structure. Minerals, though varying so widely in their outward appearance, can all be classified in this respect under one of four heads. They are (*a*) *Crystalline*, (*b*) *Vitreous*, (*c*) *Colloid*, (*d*) *Amorphous*.

Crystalline minerals are those which occur in the shape of regular geometrical solids, bounded by smooth, shining faces. A very large number of minerals are found in Nature in these forms. The phenomena of crystallisation are explained in the course of PHYSICS. It is enough here to remind the student that they always imply that the substance which presents them has been solidified from a state of fusion or solution. It is the law of Nature that every substance which is susceptible of taking on a crystalline form adheres to it under all conditions and in all places where it is found; although it must be noted that many minerals have apparently more than one crystalline form, which they assume in accordance with the physical conditions under which they are deposited. Thus, calc-spar [12] (*carbonate of lime*, $CaCO_3$) is found in Nature under many crystalline forms, such as the familiar dog-tooth spar [11], but each of these is reducible to what is known as the fundamental form of calc-spar, a rhombohedron [3]. The fundamental form of fluor-spar (*calcium fluoride*, CaF_2) [15] is a cube [1], but it is found in many other forms, such as the regular octahedron [2], each of which is a modification of the cube by the slicing off of successive corners.

Crystallography. A crystal is a geometrical solid bounded by plane surfaces. These bounding surfaces are called the *faces* of the crystal. The lines in which they meet are called its *edges*, and the point where three or more edges meet is called an *angle*. The vitally important thing in the study of crystals is that these angles always remain the same in similar crystals. A crystal as it occurs in Nature often looks very different from the trim figure of the text-book. It may have grown up under conditions which have truncated it in one direction and exaggerated it in others. But its angles always remain constant to the form to which it belongs, and by measuring them it can be assigned to its proper system with certainty. Consequently, the most important piece of apparatus used by the crystallographer is the *goniometer* (angle-measurer), which enables him to measure the angles of any crystal with rapidity and care, either by directly laying two hinged arms fitted with a scale on the faces of the crystal (*contact goniometer*) or by measuring the deflection of a beam of light which is reflected from adjoining faces (*reflecting goniometer*).

After the angles of a crystal, the most important thing to examine is its *cleavage*. All crystals have the curious property of splitting more or less readily along planes which are called *cleavage planes*, and which in all cases are parallel to the faces of a fundamental form, or to the diagonals of a face. Some crystals, like dog-tooth spar [11], can be split along their cleavage planes by a mere tap; even the diamond, though the hardest of minerals, can be shaped by chipping away its corners along the planes of cleavage. There are 32 different classes of crystals, of which all but two or three are known to occur in Nature.

The Six Systems of Crystals. These classes are divided into six systems, of which the following typical examples should be examined in a museum by the student:

System of Crystallisation	Example
(i) Anorthic	Axinite.
(ii) Monoclinic	Gypsum.
(iii) Orthorhombic	Barytes.
(iv) Hexagonal	Quartz, Calcite.
(v) Tetragonal	Zircon.
(vi) Cubic	Galena.

Enough has been said to indicate the importance of a knowledge of crystallography to the practical mineralogist. The great law of crystalline form tells us that bodies of the same chemical composition always crystallise in the same fundamental form, or in a form which can be reduced to it by simple cleavage; and conversely we know that crystals of a certain form must belong to one or other of a limited group of minerals. Often the crystal is so distinctive—like the diamond, ruby, or dog-tooth spar—that the mineral can at once be named. At any rate, we have a guide for the application of further tests.

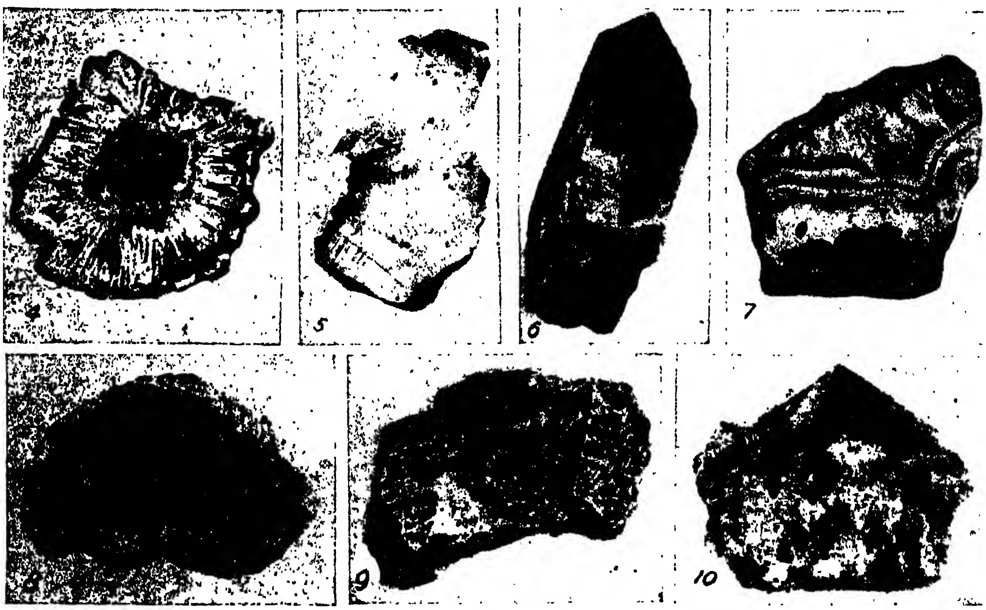
Non-Crystalline Minerals. *Vitreous*, or glassy, minerals are easily recognisable. As their names indicates, they are a kind of natural glass, which may, or may not, be translucent. Obsidian [14], the well-known "volcanic glass," is a familiar example. These minerals have mostly been fused, as in the lava of a volcano, and have cooled too quickly for crystallisation to occur.

Colloid minerals consist of a substance which reminds the observer of a petrified jelly. Silica is the most abundant mineral which takes this form. Opal [13] is a hardened variety of it.

The rest of the minerals are called *amorphous*, or shapeless, because they assume no definite form, but are found in more or less coherent masses, tufts, or granules. The soapstone [16] used by tailors, under the name of French chalk, is a good example.

Physical Properties of Minerals. Every mineral has a distinctive set of physical properties, which are of great service to the mineralogist in determining its place in the series of Nature. First comes the *specific gravity* [see PHYSICS], or weight of a mineral, compared with that of an equal volume of water. This is tested by weighing the specimen first in air and then in water; but the practical geologist soon learns to make a rough but fairly accurate guess of the specific gravity by poising the specimen in his hand.

Next in order comes the *hardness* of the specimen, which is measured in terms of a series of ten minerals ranging from talc up to diamond [see page 997]. The mineral is placed between the last which it will scratch and the first which will scratch it. The *colour* of the mineral, and of the *streak* which it leaves on paper, or which a knife leaves on it, its *lustre* and *transparency*, are also noted. The nature of its *fracture* when broken is important. It may have a characteristic *taste* or *odour*. Lastly, its *optical*, *electrical*, and *magnetic* properties have to be observed, but this usually involves the possession of apparatus, such as



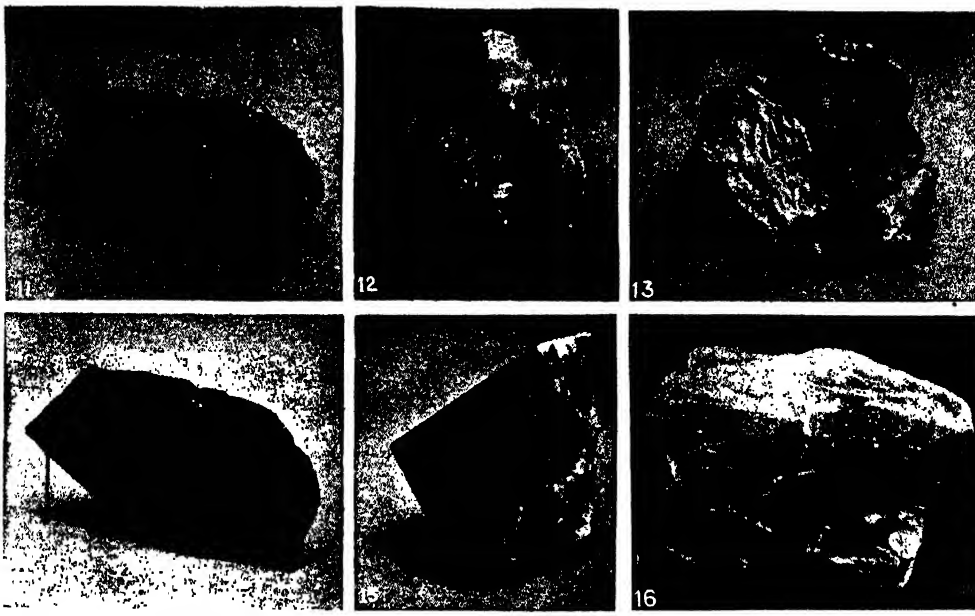
SELECTION OF THE MORE PROMINENT CRYSTALLINE AND NON-CRYSTALLINE
4. Iron pyrites (sulphide of iron). **5.** Aragonite (calcium carbonate). **6.** Smoky quartz crystal (from St. Gotthard). **7.** Banded agate (silica). **8.** Barytes (barium sulphate). **9.** Corundum (aluminium oxide). **10.** Quartz crystal (silica).

the polariscope and the electrometer, which cannot be taken into the field, and belong to the mineralogical laboratory rather than to the camp outfit.

Chemical Composition of Minerals. The only absolutely satisfactory test of a mineral is that afforded by a complete chemical analysis, which can, of course, be carried out only in a properly equipped laboratory. A few rough tests, indeed, may be applied in the field, such as the use of an acid to see if a carbonate is present, when a little carbon-dioxide (CO_2) is given off with visible effervescence. Beyond these simple tests, the business must be learnt by practice, and the average geologist is content to depute it to the chemist.

Large masses of such visitants are still lying on the soil of Greenland and Arizona. Carbon occurs uncombined in two forms—as *graphite*, or *plumbago*, which, from its property of producing a black streak on paper, is utilised in the manufacture of the so-called lead pencil; and as the most splendid of gems, the diamond, which is simply a crystalline form of pure carbon. Sulphur is also found native, as a product of volcanic action: the Spanish conquistadores obtained the sulphur for their gunpowder from the crater of a volcano.

Oxides. Certain *Oxides*, or compounds of oxygen in another element, form important constituents of the rocks. The two which we need to note here are the oxides of silicon and iron.



MINERALS THAT FORM THE ROCKS COMPOSING THE CRUST OF THE EARTH
11. Dog-tooth spar (from Matlock, Derbyshire). **12.** Calc-spar (carbonate of lime). **13.** Opal (a hardened silica). **14.** Obsidian (natural glass). **15.** Fluor-spar (calcium fluoride). **16.** Soapstone (from North Carolina).

Classification of Minerals. Minerals have been classified in various ways, but the most satisfactory system, on the whole, is that which depends on chemical composition. We shall be content to glance briefly at the twenty or thirty more important minerals which chiefly go to build up the rocks of the earth's crust. These leading minerals may be classified for convenience according to their composition under various heads—to understand which some knowledge of elementary chemistry, such as can be obtained from the course on the subject, must be assumed.

Native Elements. Certain *native elements* occur as minerals. Gold, copper, and iron are found in small quantities in the metallic form. There is reason to believe that most of the native iron found as a terrestrial mineral reached our planet in the form of meteorites.

Silica ($Si\ O_2$) is a compound of silicon and oxygen, which is best known in the form of the ubiquitous and beautiful mineral known as *quartz* [6 and 10]. It is crystalline—indeed, the Greeks called it "crystal," and held it to be petrified ice—and its fundamental form is that of a six-sided prism. But there are innumerable varieties of silica, which is the most abundant of all minerals. Some of these, like amethyst and catseye, are so beautiful as to be regarded as precious stones. Other forms of silica are chalcedony, opal, onyx, and agate [7]. Flint, on which the beginnings of human civilisation depended, is also almost pure silica, which has grown into nodules in the chalk-beds.

Iron oxides play a great part in our scenery. *Hæmatite* ($Fe_2\ O_3$), is the red oxide of iron which colours so many of our rocks—*e.g.*, red sandstone and clay (red ochre). It occurs very

abundantly, and is largely worked in the Lake Superior mines and in Cumberland. *Limonite* ($2\ Fe_2O_3 + 3\ H_2O$), or brown iron-ore, is a hydrated oxide of iron which has been largely deposited from chalybeate springs, as yellow ochre, or bog iron-ore. *Magnetite* (Fe_3O_4) is the magnetic iron oxide which was early known as the lodestone, from its remarkable property of attracting iron and of causing a needle rubbed with it to point to the north—the mariner's compass. Vast deposits of it occur in Scandinavia, and it is one of the main sources of the world's iron supply.

Corundum (Al_2O_3) is an oxide of aluminium which may be mentioned (although it does not occur largely in nature) because two of its varieties are the ruby and the sapphire, whilst in the less precious form of emery it gives us a valuable polishing material [**9.**]

Silicates. The *Silicates*—compounds of silica, or silicic acid, with various metallic oxides—constitute by far the most important group of minerals. "By themselves they constitute at least nine-tenths of the terrestrial crust, and make up practically all the rocks, except the sandstones, quartzites and carbonates." (Geikie).

The *Felspars* are composed of silicate of aluminium, combined in varying quantities with the silicates of potassium, sodium, and calcium, with traces of magnesia and iron oxide. They vary in character according to their composition. The most typical felspar is *Orthoclase*, or potash felspar ($K\,Al\,Si_3\,O_8$). It is an abundant constituent of granite. *Albite* ($Na\,Al\,Si_3\,O_8$) is the corresponding soda felspar, and *Anorthite* ($Ca\ Al_2\ Si_2\ O_8$) is a lime felspar. There are numerous other felspars of varying but generally similar composition. The group is often divided by the cleavage of its crystals into *orthoclase*, with cleavage at right angles; *plagioclase*, with cleavage at an acute angle, and *oligoclase*, with ill-defined cleavage.

Next comes the *Mica* group of silicates. All these minerals share the well-known property of common mica—that they can easily be separated into thin flakes, or *laminæ*. *Muscovite* is the common mica—of which lamp-shades and furnace-windows are made—so called because it comes from Russia, and was once known as "Muscovy glass." It is a silicate of aluminium and potassium of which no exact formula can be given as its proportions vary considerably. *Biotite* is another mica, differing in the presence of magnesium. The glittering flakes of mica are nearly always visible in granite.

The third group of silicates is that represented by *Hornblende* and *Augite*, which are bisilicates of calcium, magnesium, iron, and manganese. These two minerals are closely related, and play a considerable part in the constitution of the granitic and volcanic rocks. Allied to them are *Diallage* and *Hypersthene*. *Olivine* is a silicate of magnesium, iron, and manganese, which forms an essential ingredient of *basalt*.

The fourth group contains *Talc*—the well-known soapy mineral—and *Chlorite*, which are hydrated silicates of magnesium. *Serpentine* is of similar composition, with the addition of aluminium and iron. It is harder, but can still be cut with a knife, and gets its name from the beautiful mottling of its brown and green surface.

Carbonates. A large proportion of the rocks which form the earth's crust are composed of *carbonates*, or compounds of certain metals with carbonic acid, the gas which is produced by combustion or breathing. [See CHEMISTRY.] The most important of these is the carbonate of calcium, which occurs in nature in two forms, alike in chemical composition but differing in external appearance and physical properties. *Calcite* ($CaCO_3$), or calc-spar, is the essential basis of the great masses of limestone rock which are so abundant in many parts of the world, as in Derbyshire. It crystallises in the fundamental form of the rhombohedron. A particular variety which has become famous by its optical properties is the doubly refracting Iceland spar, which gives a twofold image of all objects seen through a transparent slice of it. *Aragonite* ($CaCO_3$) [**5**] is a harder and more durable form of calcium carbonate, which is much less abundant than calcite, and occurs in rhombic crystals. *Bitterspar* ($CaMgCO_3$) is a double carbonate of calcium and magnesium, found in greatly varying proportions of the two metals, which is chiefly interesting as the basis of the Dolomite rocks which form the great mountain masses of magnesian limestone in the Tyrol and Carinthian Alps. *Siderite* ($FeCO_3$), or brown ironstone, is a carbonate of iron often found in nodules in shaly beds.

Sulphates, Sulphides, Fluorides, Chlorides, Phosphates. The remaining minerals which, in smaller quantities, help to build up the rocks of the earth's crust, call for only brief mention here. Sulphate of calcium is found in two shapes, *Anhydrite* ($CaSO_4$) and the well-known *Gypsum* ($CaSO_4 + 2H_2O$). Sulphate of barium is barytes ($BaSO_4$), known from its heavy weight as *Heavy Spar*, which is often found in association with metal ores [**8**]. Sulphides of various metals (lead, silver, copper, zinc) are of great commercial importance, but the only one which the geologist need consider is iron sulphide, which occurs as *Pyrite* (FeS_2), known as *Iron Pyrites* [**4**] or "fool's gold," which ignorant prospectors often mistake for a valuable source of the precious metal, and as *Marcasite* (FeS_2) which plays a large part in the decomposition of rocks by its power of producing sulphuric acid on exposure to damp air. There are only two important compounds of the haloid elements found as minerals. Sodium chloride, or *common salt* ($NaCl$), is found in vast beds at places like Nantwich, where it is of great commercial importance. Calcium fluoride is the beautiful *Fluor-spar* (CaF_2) [**15**] used, from its property of giving off fluoric acid when treated with an acid by the glass etcher. Lastly, one may mention *tricalcium phosphate* or *Apatite*, which occurs in Norway and elsewhere, and has great importance to the agriculturist from its use as a fertiliser.

W. E. GARRETT FISHER

The Construction of Dams, Cofferdams, and Caissons. The Use of the Diving Bell. Tanks. The Texture of Metal.

MORE HYDROSTATIC APPLICATIONS

We have spoken hitherto of the applications of water pressure to the accomplishment of *work*. But there is another aspect of the problem which the engineer has to take account of—namely, to be sure that structures will be able to *resist* the enormous pressures to which so many of them are subjected. The law of liquid pressure is that the pressure varies as the depth, so that its increase is in exact proportion to increase in vertical depth.

The engineer, therefore, has to devise means to resist the hydrostatic pressure of water present in large quantities, and with increase in depth those difficulties grow. The most imposing examples are those of dams closing the ends of reservoirs, or barring up the waters of streams. These are among the finest pieces of work in the world. In other cases the structure takes the form of a cofferdam, or of a caisson, both being used to exclude water from areas within which men have to work in the dry.

Dams. Deep water in a quiescent state has enormous pressure. Though we associate force with water in motion, with the breakers, the ocean rollers, and the big tidal waves, these are the *dynamics* of water. But wherever the engineer goes to work far beneath the surface of still water he is confronted with the inexorable laws of hydrostatics.

Thus, take the case of a reservoir, or river barrage, the mouth of which is closed by a dam. The finest examples of dams occur at the mouth of the great reservoirs for water supply, and at the barrages of the Nile and other streams where they impound the water of floods for use in dry seasons. These dams are always built of masonry, very broad at the base. Almost invariably they are pierced with openings, having lifting gates or penstocks for the regulation of the flow. An exception occurs at Gileppe, in Belgium, where the dam is absolutely solid, and the impounded waters are led away through pipes at each end of the dam.

As the weight of a cubic foot of water is 62½ lb., that represents the weight pressing on a square foot of surface, multiplied by as many feet as the depth of the water. At a depth of 60 ft., therefore, the pressure is $62\frac{1}{2} \times 60 = 3750$ lb., or a load approaching 1⅞ tons on every square foot. Laterally, the pressure exerted at the bottom is about equal to the perpendicular force. Multiply this pressure by the total length of a dam, and the pressure is enormous.

Why Dams Collapse. It explains why, when dams have been undermined by water oozing through the foundations, which have also sloped away in the direction of the lateral pressure, they have sometimes been swept away, carrying awful destruction and death through the areas below. It explains the enormous thickness of the Gileppe barrage near Spa—72 yards through at the base.

The great Nile dam at Assuan measures 50 and 60 ft. through the base in some parts. Its piers and arches are built on a solid foundation of masonry 10 ft. in thickness and 87 ft. in width, protected by cast-iron piling from all risk of the insidious filtration of water. The piles go down 23 ft. from the surface of the masonry floor into the sand of the river bed. This dam measures rather more than half a mile in length, contains 704,000 cubic yd. of masonry, and required 824,000 cubic yd. of excavation. It cost £2,450,000, was built in three and a half years, and is able to impound 1,000,000,000 tons of water. It is pierced by 180 sluices [shown in the bottom figure, 113], which are capable of regulation, and can pass 475,000 cubic ft. of water per second, at a velocity of 20 ft. per second.

Cofferdams. Take the cofferdams and caissons just mentioned. These are the aids by which the engineer builds deep foundations in running streams and in tidal waters. Diving-bell work excepted, he has to build his foundations in the dry, even though they go down 20, 30, or 40 ft. beneath the bed of the stream. Hence, the cofferdam, or the caisson, is constructed first, enclosing an area from which the water is displaced, leaving it dry and ready for excavation, and for the laying down of masonry or concrete. The differences are, in brief, as follow.

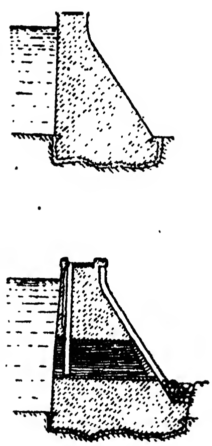
A cofferdam is usually built by piling and puddling. The structure may be round, square, oblong, or prismatic in plan view. In either case, it comprises two sets of piling—that is, there is an inner and an outer ring, or rectangle, or other form, built of squared piles, driven in close contact down their sides. Between the inner and outer rows is a space of 3 or 4 ft., which is filled with clay puddle well punned down. Of course, piling involves more than this, as cross bracing with wale pieces, sheet piling, etc., but with these details we are not concerned here. The simple point is the concentric rows of piles, with the puddled space between, by which the water is excluded from the central area, after it has been pumped dry.

This is a simple case, because if deep excavations are required, or, say, those exceeding about 20 ft. in depth, the water would burst through below the piles, and swamp the men and their work. In deep foundations, therefore, the cofferdam gives place to the caisson, which is sunk deeper in stages, as the men excavate deeper. The difficulties here are far greater than those which exist with piled cofferdams.

Caissons. A caisson is a tubular structure, usually circular or elliptical, sometimes rectangular and made of steel—though where timber is plentiful, as in America, often of wood. All around its bottom edge there is a sharp steel shoe, which is made to cut its way down into the soil by the weight of the caisson itself, or by extra loading on it. The caisson is made in sections, so that, as it sinks deeper, fresh lengths are added above to keep its mouth always above the level of the water.

Here, also, there are numerous details on which we cannot touch. But the essential fact to remember is the hydrostatic pressure. This is resisted by making the caisson very strong. Though the steel plates of which it is built do not exceed from ½ in. to ⅝ in. in thickness, they are braced together with diagonal bars to enable them to resist the water pressure surrounding them. Moreover, the lower parts are much stronger than the upper, because the pressure increases with depth.

Deep Caissons. But when caissons go down very deep, it is necessary to counterbalance the pressure of the water by opposing to it that of compressed air. That involves the separation of the working chamber from the atmosphere, and enclosing it completely, and supplying air by pumping in two atmospheres or more. That, again, involves the use of air-tight locks, with double doors for preventing outrush of air from the chamber, as often as men and materials ascend or descend. Observe **115**, which is a sectional view through the south-east Inchgarvie caisson of the Forth Bridge. This working in compressed air is very trying, and is the cause of the caisson disease, but it is all due to the pressure of the water at great depths, which, without the counter-pressure of the air, would force out the soil from the foot of the caisson, and follow it into the working area.



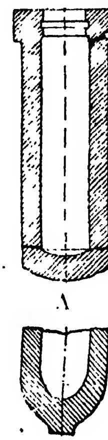
113. NILE DAM ASSUAN

Such accidents have often happened, and men have lost their lives in consequence. The water pressure is ever present to cause anxiety to the engineer, and human foresight cannot always guard against these dangers, for layers of strata of different kinds overlap, and a tough, close clay may exist over a body of sand, or denser and looser gravel and boulders may intermix, and water will find out the weak places, and the only way to prevent its ingress is by counter-pressure.

The Diving Bell. The laws of hydrostatics and of pneumatics are often found in mutual operation. We saw that in the sucking pump, and we have noted it in deep caissons. It is also apparent in the diving-bell. Down at Dover harbour works and elsewhere huge diving-bells have been at work, preparing submarine foundations for laying concrete blocks in. Men work in an atmosphere of compressed air in the bells which must be at least equal to that of the water at the depth of the bell, and is actually greater, in order to drive all, or nearly all, the water out of the bell. The air is, of course, pumped in from above.

If we consider a moment, we see that there is no essential difference between the diving-bell and the deep caisson having an enclosed working chamber. The closed chamber may be likened to the bell; and, on the other hand, the bell would only need to have a cylindrical tube attached to its roof and coming out above the top of the water, and be fitted with air-locks, to be in all respects, except details of mechanical construction, identical with a caisson.

Even in the diver's dress, water as well as air plays an essential part. It is a question of displacement of water by loading the diver with heavy clothing, without which he could not get to the bottom against the pressure due to the head of water above, which, being much greater than that of the specific gravity of his body, would force him up.

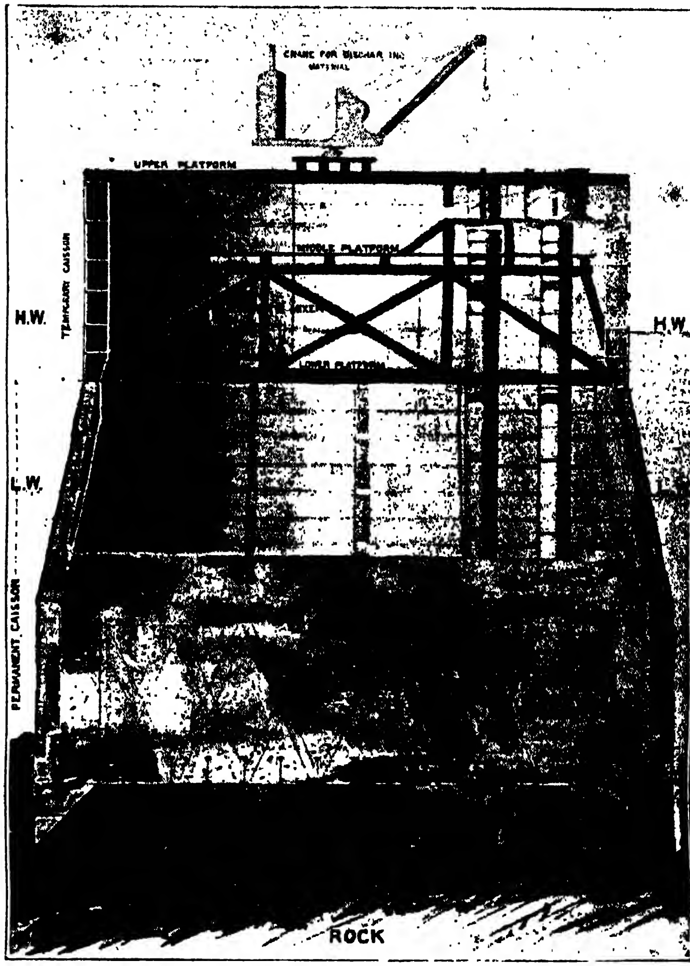


114. HYDRAULIC CYLINDER

Tanks. Hydrostatic pressure assumes a rather different aspect when tanks of metal are required from that which it takes in the reservoirs with earthen sides or in caissons. The device of having wide and well-sloped banks, as in dams, is not available in iron and steel tanks. Yet in many of these very great pressures have to be sustained. A tank only 36 ft. deep would have over a ton of load on every square foot of its bottom—thus, $36 \times 62{\cdot}5 = 2250$ lb.

There are only two materials used in tanks—cast iron and mild steel. The first are made of plates, from 3 to 5 ft. square, bolted together through flanges; the second are built up of sheets riveted together. The cylindrical form is stronger than the rectangular, but is not so readily obtainable in cast iron, so that tanks of this material are made of square or rectangular shape. Several precautions have to be taken, as follows.

As the pressure on the bottom is the greatest, and as it is difficult to make plates thick enough for the required strength, one plan is to afford a level support to the bottom, either on girders or beams, or on concrete. This applies to tanks of the largest dimensions made. For those of smaller size, a cast-iron bottom is often made, well ribbed on its lower face, the ribs reinforcing the otherwise flat weak plate, and requiring no other support. Concave and convex bottoms and conical bottoms have been proposed, the cambering in either direction affording the required strength, but such forms are neither so readily made nor so easily supported as flat bottoms are.



115. A CAISSON USED IN BUILDING THE FORTH BRIDGE

The sides of tanks are, of course, subject to greater pressure at the bottom than at the top, and therefore the plates, in the case of deep tanks, are of greater thickness as the depth increases. Thus, if the upper plates in a cast-iron tank are $\frac{3}{8}$ in. thick, the lower ones may be $\frac{5}{8}$ in. Nor is this sufficient, but the sides are held against pressure by several tie-rods passing right through from side to side of the tank and bolted fast thereto.

To render tanks watertight, they are caulked. In cast work the flanges only abut by narrow edges, leaving a depth of flange of from $2\frac{1}{2}$ in. to $3\frac{3}{8}$ in. open, and the space is caulked with rust cement, well stemmed in. Steel tanks are caulked by burring the edges with a caulking tool or chisel, precisely as boiler-plates are treated.

Molten Metal. There is another aspect of the subject which concerns liquids other than water. Who has not heard of the fluid compressed steel, the inception of which was due to the late Sir Joseph Whitworth? But that was simply an application of the principle which we have already noted as relating to the difference between a natural head of water and that artificially produced by pressure.

And the foundryman may not neglect this question of head, which is really intensified by the large difference in the specific gravities of water and of liquid iron, or steel, or brass.

At two extremes, therefore, we have the fluid compression and the natural head. The first is readily understood; the molten steel as it cools and shrinks receives artificial pressure from a hydraulic ram and pump As shrinkage continues the pressure is maintained until solidification occurs. The result is that instead of a more or less spongy ingot, from the upper part of which from one-third to one-half the length has to be cut off, to leave only the remainder as suitable for use, practically the whole is solid and sound.

Texture of Metal. To those who are unfamiliar with iron and steel, it might seem as though there could be no such thing as porosity and weakness present in them. But, unless proper precautions are observed in moulding and casting, iron and steel become so spongy that they will allow the passage of water through the pores when subject to hydrostatic test. This question of closeness of texture of metal, therefore, is a very important one. On page 1706 mention was made of the hydraulic canal lifts in France and Belgium working to a pressure of 470 lb. per square inch. This is an enormous pressure, considering the size of the cylinders—6 ft. $6\frac{3}{4}$ in.

It might be thought that there is no limit to the strength which may be ensured by making the metal in walls very thick. There comes a limit at which increased thickness does not add to strength, and this is the reason why the biggest guns are built up with layers of coiled wire, or by shrinking rings around the body. In a Belgian lift the cylinder, though 4 in. thick, was hooped round with coils of steel 2 in. thick, shrunk on. It is an old story how the press cylinder fractured during the lifting of the tube of the Britannia Tubular Bridge. The load was 1144 tons, the cylinder 22 in. bore and 8 in. thick. It fractured at the bottom of the cylinder A [114], tearing the end away. The lesson then learned is not to have a keen angle in a structure subjected to great pressure. The cylinder cast to replace this was made with a nearly hemispherical curve, also shown [B].

J. G. HORNER

The Final Chapters of Latin and English. Spanish: The Superlative, Possessive Pronouns, and Verb.

LATIN

Continued from page 1709

By Gerald K. Hibbert, M.A.

LATIN VERSE

In the first lesson it was mentioned that some syllables were short and others long—*e.g.*, mensă (nom.), mensā (abl.). These syllables are said to differ in quantity. We have now to consider *prosody*, that part of grammar which deals with the quantity of syllables and the laws of metre.

I. QUANTITY OF SYLLABLES

General rules of quantity:

1. Every diphthong and contracted syllable is long: *Mensæ*, *cōgo* (*co-ago*).

2. A vowel coming immediately before another vowel is short: *Pĭus*, *prŏhibe* (h is not taken into account in prosody, being regarded as a breathing only). There are some exceptions—*Ænēas*, *dīēi*, *Pompēi*, *fīo* (but *fĭeri*).

3. Any vowel followed by two or more consonants, or followed in the same word by *j*, *x*, or *z*, becomes long by position—*adēstis*, *āxis*.

Note. The two consonants need not be in the same word. Thus, in *jacēt corpus* the *e* is long by position before *t* and *c*, though had the second word begun with a vowel, the final syllable of *jacet* would have been short.

4. A vowel followed by a mute consonant with a liquid after it is doubtful—*e.g.*, either *lugūbre* or *lugŭbre*. But *gn* always makes a long syllable, as *īgnis*, *āgnus*.

On the Quantity of Final Syllables.

1. Most words of one syllable are long, as *mē*, *vīs*. Exceptions: Words ending in *l*, *b*, *d*, *t*, as *vĕl*, *sŭb*, *ĭd*, *ĕt*. Also *ĕs* and its compounds, *adĕs*; *quĕ*, *vĕ*, *nĕ* (enclitic—*i.e.*, joined to a word—as *amasnĕ* = dost thou love; but *nē* = lest, is long); *nĕc*, *ăn*, *ĭn*, *pĕr*, *tĕr*, *cŏr*, *ŏs* (*ossis*), *făc*, and *fĕr* (imperatives of *facio* and *fero*), *bĭs*, *ĭs*, *cĭs*, *quĭs*.

2. Words ending in *a* are long—*contrā*, *frustrā*, *amā*. Exceptions: Accusative and nominative cases, and *ită* and *quiă*. (All ablatives in *a* are long.)

3. *e* final is short—*regĕ*, *regitĕ*, *ferrĕ*. Exceptions: Cases of 1st and 5th declensions, as *diē*, *Cybelē*; imperative sing. of 2nd conjugation, as *monē*: *quarē*, *hodiē*, and adverbs derived from adjectives, as *dignē*.

4. *i* final is long—*abī*, *plebī*. Exceptions: *Sicubĭ*, *necubĭ*, *nisĭ*, *quasĭ*; also Greek vocatives and datives, as *Chlorĭ*. But *mihi*, *tibi*, *sibi*, *ubi*, *ibi*, are doubtful.

5. *o* final is long—*virgō*, *amō*, *dominō*. Exceptions: *Citŏ*, *modŏ*, *egŏ*, *duŏ*, *octŏ*, *sciŏ*, *nesciŏ*.

6. *u* final is long—*tū*, *diū*, *rectū*.

7. *y* final is short—*chelў*, *Tiphў*.

8. Words ending in *c* have their last syllable long (*illūc*), except *donĕc*.

9. Words ending in *l*, *d*, *t* have their last syllable short—*animăl*, *illŭd*, *jacĕt*.

10. *n* final is short—*nomĕn*. Exceptions: Many Greek words—*Hymēn*, *Ammōn*.

11. *r* final is short—*calcăr*, *amatŭr*. Exceptions: Many Greek words *cratēr*, *aēr*.

12. Words ending in *as* are long—*mensās*, *amās*. Except *anăs* = duck, and Greek cases of 3rd declension, as *lampadăs*, *Arcăs*.

13. Words ending in *es* are long—*sedēs*, *amarēs*. Exceptions: *Penĕs*; a few nouns like *segĕs*, *mergĕs*, and Greek plurals like *Troadĕs*.

14. Final *is* is short—*regĭs*, *similĭs*. Exceptions: Dat. and abl. plural, *mensīs*; 2nd sing. pres. indic. of 4th conjugation, *audīs*; compounds of *vīs* and *sīs*, *malīs*, *nolīs*, *velīs*, *gratīs*, *forīs*.

15. Final *os* is long—*dominōs*, *sacerdōs*. Exceptions: A few Greek words, as *epŏs*.

16. Final *us* is short—*opŭs*, *amamŭs*. Exceptions: 4th declension contracted cases, *gradūs* (gen. sing., nom. voc. acc. pl.); words whose genitive increases and has the last syllable but one long, as *tellūs*, *incūs*, *juventūs*, *virtūs*.

17. *ys* final is short—*chelўs*.

Note. Remember that all naturally short final syllables are liable to become long by position; see above, Rule 3 under general rules of quantity. Thus, the *us* of *opŭs* would become long if the word following began with a consonant, because the *u* would then precede two consonants.

II. LAWS OF METRE

Each of the following combinations of syllables is called a *Foot*:

A long syllable following a short one (˘¯) forms a foot called the *Iambus* ("satirical," because first used in satire).

A short syllable following a long one (¯˘) forms a foot called the *Trochee* ("running" or "tripping").

Two long syllables (¯¯) form a *Spondee* (so called because much used in the solemn hymns sung at a *Spondē* or drink-offering).

A long syllable and two short ones (¯˘˘) form a *Dactyl* ("a finger," from its resemblance to the joints of the finger).

Three short syllables (˘˘˘) form a *Tribrach*.

Two short syllables and a long one (˘˘¯) form an *Anapæst* ("reversed," because it is a dactyl reversed).

Scansion. Scansion is the art of counting and measuring the feet in a line or verse; when we mark off a verse into the feet which compose it we are said to scan it (*lit.* "to climb" it).

When a word ending in a vowel is followed by a word beginning with a vowel, the first vowel is dropped, or elided. This is called *Elision* or *Synalepha* ("melting together")—*e.g.*, *qui adverso* would be scanned *quād|vĕrsō*, the down-stroke marking the end of a foot.

When a word ends in *-m* preceded by a vowel, and the following word begins with a vowel, the vowel and *-m* in the first word are dropped. This is called *Ecthlipsis*—*e.g.*, *quantum est in rebus inane* would be scanned *quānt|ēst īn rēbŭs ĭn|ānē*; and *telum hæc* would be scanned *tēl|æc* [see translation of "The Lost Leader" further on].

Metres. The two commonest metres in Latin are (1) Hexameter, in which each line consists of six feet, and (2) Elegiac, in which a Hexameter line and a Pentameter (five feet) alternate. All Virgil's works are written in the former, while Ovid, Tibullus, and Propertius are the chief Elegiac poets. The only feet used in these metres are Spondee and Dactyl.

1. **Hexameter.** The first four feet may be Dactyls or Spondees; the fifth must be a Dactyl; the sixth a Spondee. Thus the scheme is:

1.	2.	3.	4.	5.	6.
◡ ◡	– ◡ ◡	– ◡ ◡	– ◡ ◡	– ◡ ◡	
	– –	– –	– –	– ◡ ◡	

Examples:

Quādrŭpĕ|dāntĕ pŭt|rēm ‖ sŏnĭ|tū quătĭt | ūngŭlă | cāmpūm

Ārmă vĭ|rūmquĕ că nō ‖ Trō|jæ qui | prīmŭs ăb | ōrīs.

A break in the words, called *Cæsura*, is usually made after the first syllable of the third foot; that is, a word usually ends with that syllable. The Cæsura is marked by the double line ‖. This is called a strong Cæsura, but if the break occurs after the second syllable of a Dactyl (as *Nōn ōmnēs ār|būstă ‖ jŭ|vānt hŭmĭ|lēsquĕ mȳ|rīcæ*), it is called a weak Cæsura.

A Hexameter must end either with a word of two syllables or of three, as "mȳricæ." It must not end with two dissyllables, nor should there be an elision between the fifth and sixth feet.

2. **Pentameter.** This line consists of two parts, called Penthemimers: the first Penthemimer contains two feet (Dactyls or Spondees) and a long syllable. The second also contains two feet—which, however, must be Dactyls—and a long syllable.

1.	2.		3.	4.	
– ◡ ◡	– ◡ ◡	– ‖	– ◡ ◡	– ◡ ◡	–
– –	– –				

It thus consists of two halves of 2½ feet each.

Examples.

Tū cĭtĭ|ūs vĕnĭ ās ‖ pōrt|ŭs ĕt āră tŭ|īs.
Lāēr|tēsquĕ sĕn|ēx ‖ Tēlĕmăc hūsquĕ pŭ|ēr

This verse is never used alone, but always follows a Hexameter in Elegiac verse, Hexameter and Pentameter alternating.

A Pentameter must always end with a word of two syllables, though sometimes *es* or *est* closes a line, the preceding vowel or *m* being cut off. The preceding word must then be a dissyllable, as *tuum est.* The last word of a Pentameter must be a substantive or a verb, or some case of *meus, tuus, suus.*

How to make Latin Verses. Having learnt the above rules of Prosody well, and being able to scan verses, the pupil will now be able to practise turning English poetry into Latin verse. The quantity of all doubtful syllables is marked in all good dictionaries (*e.g.*, săgitta), but the pupil must determine the quantity of the others by his prosody—*e.g.*, the final *a* of *sagitta* will be long or short according to whether it is ablative or nominative. A great deal of twisting and contriving will be necessary at first, but gradually it will become easier to make the verses, and often at first sight it will be evident how the line can be made to run nicely. Adjectives and other epithets may be freely inserted if needful, and *one* line of English poetry need not be expressed by *one* line of Latin verse.

The following rendering of Browning's "The Lost Leader," by the late Sir Richard Jebb, is a splendid example of versification; careful study of these lines will go far to show the pupil the necessary changes to make in the English before it can be put into Latin verse.

"THE LOST LEADER."

Just for a handful of silver he left us;
  Just for a riband to stick in his coat—
Found the one gift of which fortune bereft us,
  Lost all the others she lets us devote.
They, with the gold to give, doled him out silver,
  So much was theirs who so little allowed.
How all our copper had gone for his service!
  Rags—were they purple, his heart had been proud!

We that had loved him so, followed him, honoured him,
  Lived in his mild and magnificent eye,
Learned his great language, caught his clear accents,
  Made him our pattern to live and to die!
Shakespeare was of us, Milton was for us,
  Burns, Shelley, were with us—they watch from their graves!
He alone breaks from the van and the freemen,
  He alone sinks to the rear and the slaves!

We shall march prospering,—not thro' his presence;
  Songs may inspirit us,—not from his lyre;
Deeds will be done,—while he boasts his quiescence,
  Still bidding crouch whom the rest bade aspire.
Blot out his name, then—record one lost soul more,
  One task more declined, one more footpath untrod,
One more triumph for devils, and sorrow for angels,
  One wrong more to man, one more insult to God!

Life's night begins ; let him never come back
to us !
There will be doubt, hesitation, and pain,
Forced praise on our part—the glimmer of
twilight,
Never glad, confident morning again !
Best fight on well, for we taught him,—strike
gallantly,
Aim at our heart ere we pierce through his
own ;
Then let him receive the new knowledge and
wait us,
Pardoned in Heaven, the first by the throne !

IN LATIN ELEGIACS

(By permission of the late Sir Richard Jebb and George Bell & Sons.)

Plus ut opum minimo, clavus sibi latior esset,
sustinuit noster deseruisse suos.
Hoc modo quod nobis Fortuna negarat adeptus
perdidit, ah, quicquid nos dare fata sinunt.
Quis aurum fuit, argenti pendere pusillum :
tantula de tantis censibus ille tulit.
Hunc tenui nostrum quis non adjuverat ære ?
nostra viro sordent : munera regis avet.
Hunc amor, obsequium, reverentia nostra
colebat :
hujus erat nobis vultus ut alma dies :
"Hic Jove digna loquens, hic veri," diximus,
"auctor
dux mihi vivendi, dux morientis erit."
Mens fuit hæc Enni, fuit hæc sapientia Nævi :
vos piget hæc damnum, Calve, Catulle, pati.
Deserit hic solus nos libera signa sequentes :
servorum partes transfuga solus adit.
Ferre manet nobis—non hoc tamen auspice—
palmam ;
carminibus, sed non hoc modulante, frui ;
Bella gerent alii, lætabitur ille quiescens ;
surgere quos voluit fama, jacere volet.
Hoc quoque de fastis lacrimandum tollite nomen :
alta miser vidit, noluit alta sequi.
Hunc quoque gaudebunt Furiæ, plorabit Olympus
jus hominum summi fas violasse Dei.
Pergimus in tenebras : ne nos petat ille reversus,
ad dubios referens sollicitosque pedem.
Quo valeat laudes alienis dicere malis ?
lumen amicitiæ, quod fuit, umbra premit.
More ferox nostro telum hæc in pectora vertat,
tela recepturus pectore nostra suo :
Tum moriens nobis prior immortalia discat,
primus in æterno stans sine labe choro.

NOTE. In the above metre, which is by far the most common in Latin, the only feet used are Spondees and Dactyls. The other feet (Iambus, Tribrach, Anapæst, Trochee) are found in the rarer metres Iambic Trimeter or Senarius, and Iambic Dimeter : the Sapphic Stanza and the Alcaic Stanza. Models of the Sapphic and Alcaic Stanzas are found in the Odes of Horace [see any good edition of Horace's Odes, such as Page's].

LATIN CONCLUDED

ENGLISH

Continued from page 1711

By Gerald K. Hibbert, M.A.

HISTORY OF THE ENGLISH LANGUAGE

The history of the English language is to all intents and purposes the history of the English people. As we trace the growth of the language, we trace at the same time the growth of the nation. Words are fossilised history. They speak to us of waves of conquest, of eras of strife, of the gradual victory of the arts of peace over the arts of war ; they tell us of the hopes and fears, the expectations and disappointments, the laws, customs, dress and manners of those who have gone before us. A language should be regarded with reverence : it is too precious to be trifled with or debased. Everyone who debases the meaning of a word is as much an enemy to his country as the utterer of false coin.

Certainly we who speak the English tongue have a language of which we may be proud. It is rich in associations, and a veritable storehouse of wonders. It deserves and repays careful study.

¶ Up to about the year 450 A.D. our islands were inhabited by different Keltic races, speaking various dialects of the Keltic group of languages. These races were closely allied to the inhabitants of Gaul (as France was then called), and spoke practically the same tongue. About the beginning of the Christian Era both Britain and Gaul were conquered and overrun by the Romans, but with strikingly different results as far as language was concerned. The conquered Gauls adopted the Latin language, while Latin made singularly little impression on the Kelts of Britain, who largely retained their own dialects. The Latin language was destined, however, to have its revenge ; for the Franks and Normans, who subsequently occupied France, adopted the language of that country, and were instrumental in introducing it (in an altered form, of course) into Britain about the time of the Norman Conquest, 1066 A.D.

Keltic Words. Among the earliest elements in our language, therefore, are the old Keltic words that have survived in the struggle for existence and have come down to us through two thousand years and more. These are not many, for the language of the Britons was completely displaced by that of their Saxon conquerors.

The Keltic words consist chiefly of geographical names—*e.g.*, *Devon*, *Dorset*, *Kent*, *Exe*, *Avon*, *Ouse*, and *Usk* (all three meaning water), *Trent*, *Dee*, *Don*, *Severn*, *Wight*, *Bute*, *Pen* (as in *Penrith*). Also, as we should expect, words dealing with household matters, names of implements used by serfs, etc.—as : *barrow*, *mattock*, *mop*, *cudgel*, *clout*, *darn*, *crock*, *kiln*, *gruel* ; and indirectly (through the Norman-French) words like *flasket*, *basket*, *wicket*, *bran*, *gown*. One of the Keltic dialects is still spoken in Wales.

Early Latin Words. The Romans left singularly few words as the result of their 400 or 500 years' occupation of these islands. The Latin *castra* ("a camp") is found in plenty of place-names—as: *Chester*, *Dorchester*, *Gloucester*, *Cirencester*; *stratum* is found in *street*, *Stratford*; *colonia* in *Lincoln*; and *fossa* ("a ditch") in Fossbury.

The Coming of the Anglo-Saxons. Not long after the departure of the Romans from this country, fresh conquerors descended on its defenceless shores. From about 450 to 550 A.D. a constant succession of Jutes, Saxons, and Angles streamed over from the lowland region in north-west Germany. Conquering the Keltic inhabitants, they drove them steadily northward and westward into the lowlands of Scotland, and into Cumberland, Westmorland, Wales, and Cornwall. These tribes were of Teutonic stock. As their area of conquest extended, their language naturally became more and more prevalent, until in course of time (long before the Norman Conquest) it was spoken from the Firth of Forth to the English Channel. Out of the union of the dialects spoken by these tribes, the English language sprang. Anglo-Saxon is thus the backbone of our modern English. We shall trace the development of this particular element a little later on; meanwhile, not to lose the thread of our historical sketch, we pass on to the next great event influencing alike our nation and our language.

Second Latin Influx. The introduction of Christianity brought into the language many Latin words of an ecclesiastical nature. We may call it the period of the second invasion by the Latin language. Words thus introduced are mostly the names of Church dignitaries, ceremonies, and the like. They came either directly from the Latin, or indirectly through Latin from the Greek. Examples of the latter are *bishop*, *presbyter*, *baptism*, *eucharist*, *church*, *monastery*, *monk*, and *clergy*.

The Scandinavian Element. Meanwhile, during all these centuries, the Norsemen and Danes were constantly landing on our shores, in more or less successful attempts at conquest. These were men of Scandinavian race, whose language was of the same group as English (Teutonic). Owing to their settlement here, we have many of their words in our language to-day. A number of place-names in the north and east of England are Scandinavian—*e.g.*, Grimsby, Whitby (*by* = town); Furness, Skegness (*ness* = headland); Troutbeck, Welbeck (*beck* = brook); Orkney (*ey* = island); Aira Force, Scale Force (*force* = waterfall); Thorpe, Grimsthorpe (*thorp* = village); Dingwall, Thingwall (*thing* or *ding* = place of meeting); Langwith (*with* = wood); Lowestoft (*toft* = small field).

The Norman Conquest. The Normans introduced their language (a corrupted form of Latin) when they introduced themselves. This is the third, and perhaps the most important, invasion by the Latin tongue. Norman-French became the language of the upper classes and of the Law Courts: even to-day our Sovereign uses this language when he gives his assent to, or withholds his assent from, Bills that have passed the two Houses of Parliament. For a time, however, the mass of the English people clung tenaciously to their old language, but gradually the two races began to blend, and English assumed the form which it has to-day—a fusion of Anglo-Saxon and Norman-French. "Most of the words in our language which relate to feudal institutions, to war, law, and the chase, were introduced in this way." (Mason.) As was pointed out in the introductory article to the Study of Languages [page 114], one of the chief effects of the introduction of Norman-French was the gradual disuse of the grammatical inflexions of Anglo-Saxon. Under its influence our language has become largely analytic instead of being synthetic or inflexional.

It may be noted that the town-crier perpetuates a Norman-French word in his "O yes," which really is "Oyez," the imperative of *oyer*, to hear.

The Revival of Learning. What is called the "Renaissance," the great revival of the study of the classical languages in the sixteenth century, gave an immense number of Latin words to our language. This is the fourth, and practically the last, invasion on the part of Latin. A perfect craze arose for using long, cumbersome, and unwieldy words taken straight from Latin, and even from Greek. The authors of this period and school are often painful reading. For example, Trench gives the following uncouth creations: "Torve and tetric = *stern*, *severe* (Fuller); cecity = *blindness* (Hooker); insulse = *tasteless* (Milton); facinorous = *guilty* (Donne); sufflaminate = *to put the drag on* (Barrow); moliminously = *with effort* (Cudworth); immarcescible = *unfading* (Bishop Hall); luciferously = *bringing light* (Brown)."

Many of the words thus introduced have long since perished, and during the last hundred years or so there has been a strong reaction in favour of a return to a purer Anglo-Saxon diction.

In many cases the same Latin word has given us two words in English, one coming direct from the Latin, the other through the medium of Norman-French. For example:

Latin.	*Direct from Latin.*	*Through Norman-French.*
Fragilis	fragile	frail
Ratio (-nem)	rational	reason
Potio (-nem)	potion	poison
Quietus	quiet	coy
Punctum	punctuate, etc.	point
Factum	fact	feat

Similarly, *hospital* and *hotel*, *blaspheme* and *blame*, *pauper* and *poor*, *redemption* and *ransom*, *senior* and *sir*, *rotund* and *round*, *junction* and *joint*.

Miscellaneous Words. In later times English has borrowed words from almost every language under the sun; as our borders have extended, and as our commerce has grown, so has our language become more and

more cosmopolitan. Some of the chief of these sources may be mentioned:

Chinese. Caddy, junk, gong, nankeen, tea.

Turkish. Bey, ottoman, sash, tulip, janissary.

Persian. Bazaar, altar, sherbet, turban, chess, dervish, hookah, lilac, musk, taffeta.

Hebrew. Sabbath, seraph, cherub, amen, leviathan, jubilee, Satan, ephod.

Arabic. Alchemy, alcohol, algebra, almanac, alembic, tariff, zenith, zero, nadir, talisman, naphtha, coffee, mosque, fakir, giraffe, harem, sultan, vizier.

Hindustani. Muslin, calico, rupee, lac, pundit, sepoy, thug, suttee, chutnee, jungle, pariah, nabob, bungalow, coolie, curry.

French. Etiquette, soirée, menu, eau-de-vie, chef, ennui, bouquet, bon-bon, trousseau, carte-de-visite, tête-à-tête.

Spanish. Alligator, armada, matador, toreador, battledore, galleon, cargo, bolero, eldorado, tornado, renegade, verandah, castanets, chocolate, don, negro, mulatto, grandee, pillion.

Italian. Banditti, maccaroni, folio, quarto, stiletto, stucco, incognito, gazette, brigand, gondola, influenza, motto, opera, concert, and nearly all the terms used in music.

Dutch. Boom, schooner, sloop, skipper, yacht, reef, skate.

Gaelic. Clan, tartan, pibroch, slogan, plaid.

Portuguese. Caste, cocoa, palaver, porcelain, marmalade, commodore, fetish.

Polynesian. Taboo, tattoo, boomerang, kangaroo, wombat, wonga-wonga.

American Indian. Squaw, wigwam, pampas, papoose, tobacco, tomahawk, maize, pemmican, potato, hammock.

Scientific words employed in botany, medicine, etc., are mostly derived from Latin or Greek.

The Five Periods of English. It is possible to trace five distinct periods or stages through which the English language has passed.

1. EARLY ANGLO-SAXON. This period extends practically up to the time of the Norman Conquest, at the close of the eleventh century. There were two main dialects of the language—the *Anglian* in the north and the *Saxon* in the south. Gradually the East Midland variety of the Anglian branch (spoken in the district round Oxford and Cambridge) spread to London, and became the parent of modern standard English.

2. LATE ANGLO-SAXON. This lasted from about 1100 A.D. to 1250 A.D. The most noticeable feature is the influence of Norman-French. The Normans would not trouble to learn the Anglo-Saxon inflexions, consequently the language began to lose its inflexions, and many of its distinctions vanished.

3. OLD ENGLISH. This lasted from about 1250 to 1350 A.D. The weakening influence of Norman-French was still more pronounced, and the language became rapidly analytic. The English of these first three periods is very different from that of to-day, and needs to be studied almost as though it were a foreign tongue.

4. MIDDLE ENGLISH. But when we come to this period (1350-1500), of which Chaucer is the shining light, we approach much nearer to our modern language. A great deal of Chaucer can be read right off by any English-speaking person of average education. It was during this period that the East Midland dialect became predominant.

5. MODERN ENGLISH. 1500 to the present day. This brief review helps us to see that the two chief elements in the English language are Anglo-Saxon and Latin, or (as we may also call them) the Teutonic element and the Romance element. The former was introduced into this country by the Angles and Saxons, and to a less degree by the Danes and Norsemen; the latter came in, as we have seen, either directly or through the medium of Norman-French.

Teutonic v. Romance. These two elements have blended together to form our modern language. But we must never forget that the basis, or framework, is Teutonic or Anglo-Saxon. It is true that there are more than twice as many classical or Romance words in our language as Anglo-Saxon, the numbers given by some authorities being respectively 29,000 and 13,000. Yet the majority of those used belong to Anglo-Saxon, and when we want to express our finest feelings, or to interpret the deepest things of life, we naturally resort to that language. It is at once the simplest and the most dignified. A wise writer, of course, will avail himself of both elements; in fact, he cannot help himself. But he will see to it that while the superstructure may be Romance, the basis of his language will be Anglo-Saxon. He will never choose a classical word when a Teutonic one will do equally well. As a rule, the Teutonic words are the shorter. Most words of three or more syllables, and many of those of two, are classical; while in most words of one syllable, and very many of two, the Teutonic element prevails.

Teutonic Elements in English. The following are the chief Teutonic elements in our language: Pronouns, numerals, prepositions, conjunctions, adjectives of irregular comparison, auxiliary verbs, all verbs of strong conjugation, and some of weak; also most words relating to house, farm, family, parts of the body, common natural objects, common actions and things, trades, etc. On the other hand, words relating to law, religion, government, war, science, art, philosophy, are mostly classical.

One great advantage given to the English language by this blending of two distinct elements is that it is particularly rich in words of similar though not identical significance. It can, therefore, express delicate shades of meaning that are impossible to other languages. Notice, for example, the following list of pairs, one word being Teutonic, the other classical:

Teutonic.	*Classical.*	*Teutonic.*	*Classical.*
cold	frigid	breadth	extent
hard	difficult	wedlock	matrimony
bitterness	acerbity	feeling	sentiment
God	deity	life	existence
work	labour	love	passion

Teutonic.	*Classical.*	*Teutonic.*	*Classical.*
maw	stomach	world	universe
bloom	flower	worship	adoration
hearers	audience	fire	conflagration

This list might be extended almost to any length. It will be noticed that, on the whole, the Teutonic words are more "nervous" and expressive than the classical. As a rule, they come first to one's mind, the others being employed subsequently to avoid repetition, or to amplify the meaning. Naturally, our finest poetry is largely composed of the Teutonic element. Shakespeare is well worth studying from this point of view alone. The Authorised Version of the Bible, Bunyan and Defoe contain whole paragraphs composed almost entirely of Saxon words. For simplicity and pathos there is nothing to beat Anglo-Saxon. What is the charm of such a piece as, say, Tennyson's "Crossing the Bar"? Surely it is the fact that it contains hardly any but Saxon words:

Sunset and evening star,
And one clear call for me,
And may there be no moaning of the bar
When I put out to sea.

But such a tide as moving seems asleep,
Too full for sound and foam:
When that which drew from out the
boundless deep
Turns again home.

Twilight and evening bell,
And after that the dark:
And may there be no sadness of farewell
When I embark.

For tho' from out our bourne of time and place
The flood may bear me far,
I hope to see my Pilot face to face
When I have crossed the bar.

How many words of classical origin can you count there?

Perhaps the best modern example of the classical style is to be found in the works of the late Frederick William Farrar. If we open them at any page, we find majestic, sonorous sentences, almost every other word of which is of classical origin. For example:

"Christ willed that they should be husbands, and fathers, and citizens, not eremites or monks. He would show that He approved the brightness of pure society, and the mirth of innocent gatherings, no less than the ecstasies of the ascetic in the wilderness or the visions of the mystic in his lonely cell. . . . Christ came not to revolutionise, but to ennoble and sanctify. . . . He came to teach that the service which God loved was not ritual and sacrifice, not pompous scrupulosity and censorious orthodoxy, but mercy and justice, humility and love. He came, not to hush the natural music of men's lives, nor to fill it with storm and agitation, but to re-tune every silver chord in that 'harp of a thousand strings' and to make it echo with the harmonies of heaven."

Relation of English to Other Languages. The languages of the world are arranged in families, according to resemblance in grammar and vocabulary. One of these families is known as the *Indo-European*, or *Aryan* family. It includes:

1. *Sanscrit*, which is the classic language of India, and exhibits the Aryan grammar in its most perfect form.

2. *Persian*, the earliest literary form of which is called Zend.

3. *Slavonic*, including Russian, Polish, Lithuanian, Lettish, etc.

4. *Græco-Latin*, including Greek and Latin, together with the "Romance" languages derived from Latin, such as French, Italian, Spanish, and Portuguese.

5. *Keltic*, comprising Gaelic (*i.e.*, Irish or Erse, Manx, and Scottish Gaelic), and Cymric (*i.e.*, Welsh and the Armorican of Brittany).

6. *Teutonic.* This group is divided into two main sections, Scandinavian and German. Scandinavian includes Icelandic, Swedish, Norwegian, and Danish. German comprises High German (the languages spoken in South Germany) and Low German (the languages spoken in the northern lowlands of Germany). To this latter section (Low German) English belongs, and has, for its nearest neighbours, Frisian, Dutch, Flemish, and Platt-Deutsch.

Not all the European languages are of Indo-European stock. Turkish, Finnish, and Hungarian (*i.e.*, Magyar), for example, are of a different stock. They have been introduced from Central Asia in comparatively modern times.

Grimm's Law. In addition to words that have been imported into English, there are many English words, or roots of words, that are common to most of the Aryan languages. These have not been borrowed by one from another, but all the different languages have received them from some earlier source. It has been noticed that in each set of these words common to several Aryan languages there is a certain relation existing between the consonants. The expression of this relation is known as "Grimm's Law," because it was stated by Jacob Grimm (1785–1863). It is given by Mason as follows: "If the same roots or the same words exist (1) in Sanscrit, Greek, Latin, etc.; (2) in Gothic or the Low German dialects; and (3) in Old High German, then

1. When the first class have an aspirate, the second have the corresponding soft check (*i.e.*, flat mute), the third the corresponding hard check (*i.e.*, sharp mute).

2. When the first class have a soft check (flat mute), we find the corresponding hard check (sharp mute) in the second class, and the corresponding aspirate in the third.

3. When the first class have a hard consonant (sharp mute), the second class have the aspirate, and the third the soft check (flat mute). In this third section of the rule, however, the law holds good for Old High German only as regards the *dental* series of mutes, the flat guttural being generally replaced by *h*, and the flat labial by *f*.

Examples.

Greek	Latin	Sanscrit	English	Gothic	Old High German
1.					
chēn	(h)anser	hansa	goose	gans	kans
thēr	fera		deer	dius	tior
phero	fero	bhri	bear	baira	piru
2.					
gnomi	gnosco	jnâ	know	kan	chan
deka	decem	dasan	ten	taihun	zehan
kannabis	—		hemp	—	hanaf
3					
kardia	cordis	hridaya	heart	hairto	(herza)
treis	tres	trayas	three	threis	dri
huper	super	upari	over	ufar	ubar

The student will find it interesting to take other words, such as *garden, daughter, door, dare, middle, brother, beech, be, kin, knee, foot, two, tooth, help, thou, other, father, full, fish,* etc., and trace their relationship with kindred words of other Aryan languages along the lines of this general law. English thus ceases to be an independent language, arbitrarily invented for our exclusive use. We see it to be a gradual growth, a single member of a large family of tongues, with brothers and sisters, nephews and cousins, closely related to it on all sides. It thus falls into its place in the general scheme of evolution.

ENGLISH CONCLUDED

SPANISH

Continued from page 1590

By José Plá Cárceles, B.A.

Superlative of Adjectives. The relative superlative [see page 1447] is formed [see page 1035] by putting *el más, la más* (the most), in front of the positive adjective.—*el más alto,* the highest; *el más negro,* the blackest.

A superlative of inferiority is obtained in a similar manner by using *el menos, la menos* (the least).—*el menos rápido,* the least quick.

The absolute superlative, which in English is made with the adverbs "very," "most," "extremely," is formed in Spanish by placing *muy* before the positive adjective, or by affixing to it the terminations *ísimo, ísima, ísimos, ísimas,* according to the gender and number of the noun it qualifies. —*fácil, muy fácil, facilísimo,* easy, very easy, most, extremely easy. If the adjective ends in a vowel, the terminations are affixed after dropping the final vowel.—*grande, muy grande, grandísimo,* large, very large, extremely large.

Adjectives ending in *co, go, ble, z,* change those letters into *qu, gu, bil, and c,* before affixing the superlative terminations.—*notable, notabilísimo,* notable, very notable.

Among important superlatives irregularly formed are the following: *fuerte* (strong), *fortísimo; bueno* (good), *bonísimo; nuevo* (new), *novísimo; fiel* (faithful), *fidelísimo; sabio* (wise), *sapientísimo.* Some adjectives have an irregular absolute superlative, besides that ending in *ísimo.* The principal are: *bueno* (good), *óptimo; malo* (bad), *pésimo; grande* (large), *máximo; pequeño* (small), *mínimo; alto* (high), *supremo; bajo* (low), *ínfimo.*

Possessive Pronouns. The possessive pronouns are as follow:

Singular		Plural	
mío,	mine	*nuestro,*	ours
tuyo,	thine	*vuestro,*	yours
suyo,	his, hers, yours	*suyo,*	theirs, yours.

Possessive pronouns agree in gender and number with the substantive to which they relate, and are preceded by the definite articles *el, la, los, las.*—*el ha traido sus cartas, pero yo he olvidado las mías;* he has brought his letters, but I have forgotten mine.

In sentences formed with the verb "to be," meaning "to belong to," the words *el, la, los, las,* are omitted.—*esa caja no es nuestra;* that box is not ours. When the possessive pronouns are preceded in English by "of," this preposition as well as the article is always omitted in the Spanish phrase.—*un libro suyo* (*de ella*); a book of hers.

The possessive adjectives "my," "his," "your," and so on, are sometimes translated by the possessive pronouns, and then placed after the noun they qualify in order to emphasise their meanings.—*eso no es deber mío;* that is not my duty. As in the case of the possessive adjectives, *de él, de ella, de Vd,* and so on should sometimes be used instead of *suyo, suya,* and the like, for the sake of clearness.

IMPERFECT INDICATIVE OF *Ser*

Singular	*Plural*
era, I was	*éramos,* we were
eras, thou wert	*érais,* you were
era, he, she was, you were	*eran,* they, you were

IMPERFECT INDICATIVE OF *Estar*

Singular	*Plural*
estaba, I was	*estábamos,* we were
estabas, thou wert	*estábais,* you were
estaba, he, she was, you were	*estaban,* they, you were

The imperfect indicative can also be translated "I used to be," and so on.

Sentences formed with "was," "were," and a present participle are sometimes literally translated. The student must then bear in mind that, in all phrases of this kind, "to be" must always be rendered by *estar,* not *ser,* as the sentence then conveys the idea of what was being done at the time of reference only; thus, she was singing, *estaba cantando.*

IMPERFECT INDICATIVE OF *Tener*

Singular	*Plural*
tenía, I had	*teníamos,* we had
tenías, thou hadst	*teníais,* you had
tenía, he, she, you had	*tenían,* they, you had

IMPERFECT INDICATIVE OF *Haber*

Singular	*Plural*
había, I had	*habíamos,* we had
habías, thou hadst	*habíais,* you had
había, he, she, you had	*habían,* they, you had

Exercise XVIII

expensive	*caro*	short	*corto*
exercise	*tema*	difficult	*difícil*
phrase	*frase*	easy	*fácil*
to affirm	*afirmar*	happy	*feliz*
to think	*creer*	neither—nor	*ni—ni*
or	*ó*	mistake	*equivocación*
I do not know	*no sé*		

1. Whose hat is this? 2. Mine. 3. Have you sold his goods or mine? 4. I have neither sold his nor yours. 5. Is your house more expensive than ours? 6. I do not know, but I think ours is most expensive. 7. Her exercises are the shortest, but they are most difficult. How are yours? 8. Mine are easier than hers. 9. He is not my friend. 10. A phrase of his. 11. They are extremely happy. 12. They affirm those mistakes are not theirs.

Imperfect Indicative of Regular Verbs. The *first conjugation verbs* form the imperfect indicative by adding to the stem the terminations *aba, abas, aba, ábamos, ábais, aban.* Verbs of the *second* and *third conjugations* add the terminations *ía, ías, ía, íamos, íais, ían.*

Imperfect Indicative of *Comprar*

Singular		*Plural*	
compr-aba,	I was	*compr-ábamos,*	we were
compr-abas	buying	*compr-ábais*	buying
compr-aba		*compr-aban*	

Exercise XIX

to change	*cambiar*	to govern	*gobernar*
to hide	*ocultar*	to fight	*luchar*
to hire	*alquilar*	to spend	*gastar*
to snow	*nevar*	key	*llave*
motor-car	*automóvil*	estate	*hacienda*
absent	*ausente*	top	*cumbre*
mountain	*montaña*	while	*mientras*
at home	*en casa*	soldier	*soldado*
to administer	*administrar*	to help	*ayudar*
a great deal of	*mucho*	advertisement	*anuncio*

1. He used to change all his banknotes at the post-office. 2. She used to hide the key. 3. I used to hire a motor-car every morning. 4. They used to administer the estate while the owner was absent. 5. The soldiers were fighting on the top of the mountain. 6. The old firm used to spend a great deal of money in advertisements. 7. I was not at home that day. 8. It had been snowing the whole morning.

Imperfect Indicative of *Beber*

Singular		*Plural*	
beb-ía,	I was	*beb-íamos,*	we were
beb-ías	drinking	*beb-íais*	drinking
beb-ía		*beb-ían*	

Exercise XX

to dine	*comer*	to do	*hacer*
to run	*correr*	to light	*encender*
to sell	*vender*	to sew	*coser*
work	*trabajo*	Continent	*continente*
low	*bajo*	price	*precio*
fire	*fuego*	young	*jóven*
to read	*leer*	to rain	*llover*

1. I used to dine with my English friends. 2. His horse used to run more than mine. 3. She used to do my work when I was on the Continent. 4. Was it you who were knocking at the door? 5. Who used to light the fire in your room? 6. They used to sell at lower prices. 7. She used to sew a great deal when she was young. 8. We used to read when it was raining.

Imperfect Indicative of *Cumplir*

Singular		*Plural*	
cumpl-ía,	I was	*cumpl-íamos,*	we were
cumpl-ías	fulfilling	*cumpl-íais*	fulfilling
cumpl-ía		*cumpl-ían*	

Exercise XXI

to write	*escribir*	to sleep	*dormir*
to open	*abrir*	to distribute	*distribuir*
to live	*vivir*	to come	*venir*
to correct	*corregir*	nearly	*casi*
camp	*campamento*	window	*ventana*
profits	*ganancias*	among	*entre*
mail	*correo*	near	*cerca*
river	*río*	early	*temprano*
at that time	*entonces*	exercises	*temas*
bookkeeper	*tenedor de libros*		
at daybreak	*al amanecer*		
shareholders	*accionistas*		
teacher	*profesor*		

1. We used to write nearly all their letters. 2. The soldiers used to sleep in the camp. 3. He used to open all the windows. 4. They used to distribute the profits among the shareholders. 5. We were living near the river. 6. Who was the bookkeeper at that time? 7. They had no agents in Paris. 8. She used to come very early. 9. The teacher used to correct his exercises. 10. We used to receive the mail at daybreak.

Key to Exercise XV

1. (Yo) uso sobres grandes. 2. Mi amigo emplea dos criados. 3. (Nosotros) no avisamos á nuestros clientes. 4. ¿ Firma el secretario todos los cheques? 5. No giran á la vista. 6. ¿ Hablan todos los empleados español? 7. No viaja en invierno. 8. No aceptan nuestras condiciones. 9 ¿ Trabajan muchas horas diariamente? 10. ¿ Toma Vd. té ó café? 11. Tomo café con leche, gracias.

Key to Exercise XVI

1. Aprende idiomas extranjeros. 2. Ese caballo corre muy de prisa (or, better, mucho). 3. ¿Come Vd. mucho pan? 4. El tendero no vende mucho ahora. 5. ¿ No comprenden su explicación (de Vd.)? 6. Creo que no son ingleses. 7. ¿ Por pué no contestan? 8. Por que temen las consecuencias. 9. Yo no prometo eso. 10. Debemos tres trimestres.

Key to Exercise XVII

1. No vive aquí ahora. 2. ¿ Recibe Vd. noticias de América todas las semanas? 3. ¿ Por qué no admiten niños? 4. No discutimos eso. 5. Los precios suben muy raramente en la primavera. 6. ¿ Qué decide Vd? 7. Nunca cumple sus promesas. 8. ¿ Quién reparte el dinero? 9. Surtimos á varias casas europeas. 10. No asisto á todas sus reuniones.

Continued

How to Take Patterns from Models. Copying Shapes from Measurement. Shape-making. Shaping the Tip. The Process of Mulling.

PATTERNS & SHAPE-MAKING

The advantage of being able to take patterns correctly is very evident, as the newest shapes are never "blocked" or sold retail.

A milliner buys the trimmed models, and takes the pattern of them to copy either in a wire shape or to cut out in espatra or buckram for firm shapes to be covered with cloth, velvet or silk. The experienced milliner is very quick at seeing what will be the best way to set about it, as in a much curved and trimmed hat or toque it is not so easy at first to get at the actual shape. It may sometimes be necessary partly to take off the trimming.

Taking the Pattern. A paper pattern is taken in three parts: the brim, the sideband, and the tip, each part being taken off before the next is begun to avoid tearing the paper. Unless it is a toreador, turban, pork pie, or pillbox shape hat—all of which have an edge to the brim—the brim pattern can be taken in one piece.

Brim. The pattern is taken either from the inside or outside of the hat—whichever is more easy to get at. Take a piece of good tissue paper, place it with the corner to centre-front of brim, pin it with a steel pin, and smooth it away on either side until the brim is entirely covered without a wrinkle. Avoid placing the pins in a row, as that is likely to give fulness between [22]. Pin round the headline: cut away the paper round the edge, holding the hat in the left hand and the scissors in the right. See that the paper is cut *exactly* to the headline. Mark centre-front with small "snick" △.

Take out the pins, fold the paper in half, and see that the two sides are exactly alike; the edges may require cutting. (This applies to a plain hat with both sides alike.) In cheaper bought shapes of buckram and straw, which are often one-sided, select the side which appears the better shape, and mould the other half to that. If the paper is not large enough, or the brim is too much fluted to be taken in one piece, join on pieces wherever necessary.

Sideband. For the sideband, start again from the centre-front, smooth and cut the paper wherever necessary on either side till it reaches the back [23]. Cut away along the top edge, and continue snipping the paper round the bottom till it can easily be cut away round the headline.

Snick for centre-front, and, in the case of the join coming at the side, snick also the centre-back. The join comes on the sideband wherever it is most likely to be covered with the trimming.

The Tip. The "tip" of a hat is generally round, oval, or diamond, and it is therefore unnecessary to take the pattern, for when the sideband is joined to the brim the shape of tip can readily be found.

In toques and bonnets the pattern must always be taken, as there are so many kinds of fancy shapes. If the pattern is likely to be much used, run it on stiff net with fine cotton, cut the net to shape, and keep for future use, keeping all the parts of a pattern pinned together.

In "turban" [40] hat brims, the second edge is often merely a straight piece, in which case it can be measured and cut out in paper; if, however, it is ever so slightly shaped, a paper pattern should be taken.

Round Dome Crowns [24]. No pattern is taken of these, as they can be made from a blocked shape.

Oval Crowns [25]. This shape may be taken in two pieces—the sides and tip.

Toques and Bonnets. Patterns of toques and bonnets are taken in the same way as hats. Bonnets of the Dutch [26] or Marie Stuart [27] type may be taken in one piece. The *Coronet* is a fancy-shaped brim in the front side or back of a bonnet. Such shapes as the Granny and Véronique bonnets must be taken in separate parts, as described for hats.

Rough Straws. If it is impossible to take the pattern of rough or fancy straws in paper, use pieces of stiff net or leno of about 2 in. square. Lay the pieces on the upper side of brim, each overlapping a little, and pin down.

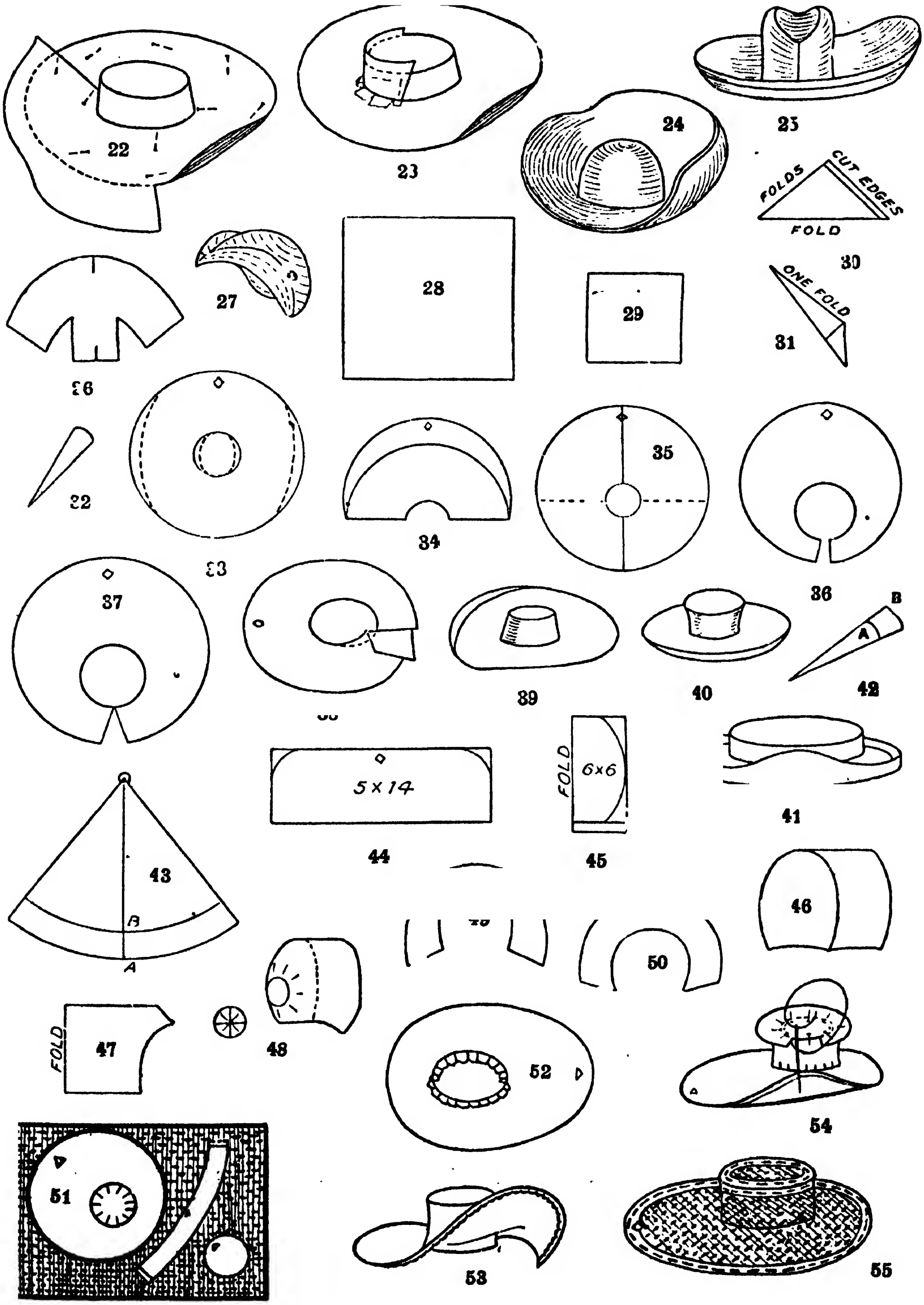
Cut the outer edge and headline of pattern to shape of hat, and make a snick for centre-front. Take pattern carefully from the hat. Pin this net shape on to a piece of paper or a large piece of net, and cut out the pattern again.

To correct the pattern, fold it in half and check it, modelling from the side which looks the better. If there is any difference in size at headline, keep the shape of that which has been less cut away.

If straight, take the pattern of sideband by measurement, having the join at back, and allowing no turnings.

Copying Shapes by Measurement. To copy a shape by measurement, which would be done if a wire shape is required, proceed in this order:

1. Headline. Pin the inch tape at the starting point, and work from right to left.
2. Outside edge.
3. Width of brim, centre-front, sides and back.
4. Diagonal of brim—(*a*) side-front right, (*b*) side-front left; (*c*) side-back right, (*d*) side-back left.
5. Diameter of brim—(*a*) front to back, (*b*) side to side.
6. Depth of sideband.
7. Size round tip.
8. Diameter of tip—(*a*) front to back, (*b*) side to side.
9. Width between wires round edge.



22 55. SHAPE-MAKING FOR HATS AND BONNETS.

Take the measurements from the *inside* of model where possible, and make a note of any peculiarity of shape. If the pattern of a trimmed model is taken, measure all the trimmings, noting position of feathers, etc. Write them down in a notebook.

If an espatra shape is required, obtain the measurements and then take a large square of paper, fold it in half, draw the headline and cut it out. To obtain the radius, divide the size of head by 3, and this will be the diameter of the circle; halve this, which will be the radius. Open out the paper, mark all the different measurements from the headline. Proceed in the same way for the sideband and tip.

After some experience, it will be easy to make up one's own patterns, beginning in this way:

Cut a square of paper the diameter of the hat to be made [28].

Fold it in half, then in half again, thus making a square [29].

Fold it diagonally [30], and diagonally again, always keeping the folded edges of the paper together, and placing the new fold on the separate folds [31].

Cut off the triangle beyond the double part, slightly sloping it. If sloped too much, flutes will be formed round the edge [31].

Open it out, and it will be found to be a circle.

Refold, and from the centre point measure one-sixth of the headline, which should be cut off [32]. This gives a round brim with round headline, only suitable for children and young girls. For adults, the headline is mostly oval, which is obtained by sloping off ½ in. along each side [33].

To make a brim wider in front than at the back and sides, instead of folding the circle in half fold it 1 in. or 2 in. from the front [34]; refold, and cut headline as before [35].

For shapes like the Gainsborough [36], larger on one side than the other, cut the larger side first, and shape the smaller side *after* the headline is cut.

After getting the circle of paper with the headline cut out, any shape may be made, according to fancy. An oval-shaped brim may be cut by sloping ½ in. to 1½ in. away from each side.

Half an inch taken from centre of back, sloping to a point in headline, will cause the brim to turn up or down [37]. A gusset, inserted either at the left side or the side-back, will cause the brim to be very much curved [38].

Small cuts sewn together, slightly overlapping, will turn the brim up round edge, as for French sailor hats and similar shapes. Thus, with a little originality and ingenuity, any kind of shape can be evolved.

Sidebands. In making shaped sidebands more curve is required for those which are narrower at the top than at the bottom, and vice versâ [39 and 40]. The straighter the sideband, the less the curve should be. For a sideband that is nearly straight very little curve is required. Straight sidebands, not wider than 3 in., may be cut on the cross of the spatrie and slightly stretched top or bottom [41].

Take a square of paper of about 20 in. Proceed to fold it in the same way as for brim until a circle is obtained. Measure the depth of the sideband from outer edge, B [42]. Open paper out and measure along bottom the size of headline. Measure along the top, A, about 2 in. less and cut off along the curved lines. No pattern need be made of the tip as it is fitted to the sideband when the shape is made up.

Another method of obtaining the same result is to take a piece of paper, fold it in half, and mark the centre at top. Hold the end of a tape measure on this mark and make A at 15–18 in. down. Sweep to either side of A [43]. Measure upwards 2½ in. or 3 in., according to size required, mark B, and sweep round again.

Measure along curve from A half the size of headline. Mark each side and draw a line from the pivot to these points. Cut along the curved lines.

Fancy patterns of toque shapes should be made in wire from measurements taken. They would be difficult to copy in hard materials, as these do not lend themselves to such manipulation.

Children's hats and bonnets may be drafted from measurements. For hats, only one measurement is required—size of head. For bonnets there are four measurements: Over the head to below the ears, 14 in.; ear to ear, round back of head, 5 in.; forehead to nape of neck, 11½ in.; forehead to centre crown at back of head, 5 in.

Cut length of paper to correspond in length with the first measure and in width with the fourth measure [44]. Round the corners.

For the back of the bonnet, cut a square of paper the size of third, less the fourth measure [45]. Make a circle from the square. Fold it in half and cut off 1 in. to 1½ in. to form an oval.

Cut off 1 in. from the bottom. For "Coronets," with revers (the patterns of which are made separately) [49 and 50], place the front of bonnet flat on the table, pencil round the shape on paper and draw the shape and width required.

The cutting out, making, and trimming of the bonnet shown in 46, 47, and 48, are described when dealing with Children's Millinery.

SHAPE-MAKING

Having learned to take patterns, we will proceed to make the shape. The best milliners usually make their own shapes, as they are much lighter, fit better, and possess more individuality. The block shapes bought in shops are turned out by the thousand, and are mostly made of an inferior kind of buckram, badly wired, and, in some cases, the different parts are only gummed together.

We will take first "winter" shapes, which have to be covered with velvet, cloth, silk or fancy millinery material. The best material for shape-making is espatra, known in the trade as "spatrie."

It is made only in white in sheets 24 in. by 31 in., and in two kinds, stiff and soft. The stiff is used for straight or very slightly curved

brims and crowns. The soft spatrie is better for the curved brims of hats, toques, and coronets of bonnets. It is easier to manipulate as it stretches; or can be eased on the wire. It also makes the shape lighter in weight. If espatra is not obtainable, millinery buckram is the best substitute, made only in black and white, and sold by the yard.

Open out the pattern and place it on the espatra with the front (which was marked in each piece with a "snick") to the corner. Remember that *all parts* are cut with the centre-front placed on the cross [**51**]. Pin the pattern firmly on the espatra, leaving these turnings: (1) ½ in. turning inside headline; (2) ½ in. at each end of sideband.

If the brim is cut at the back (**36**], in order to overlap or sew in a gusset, leave ½ in. turning each side.

Mark *on* the espatra the centre-front of each part; cut out and remove the pattern.

Making up the Shape. Snick the ½ in. turnings left inside the headline, ½ in. apart, and turn back to rough side, defining well the headline [**52**].

All parts of the shape must now be wired, using the wire stitch, one wire coming to two edges. Use firm support wire.

Brim. Wire headline on rough side of espatra outside the turnings [**52**]. Overlap the wires for 2 in. wherever they join. Wire edge of brim on the muslin or smooth side of espatra at the extreme edge [**53**]. Sew another (finer) wire ½ in from the edge on the under part of the brim [**53**].

Sideband. Pin centre-front to centre of front of brim, the smooth side of the spatrie coming outside [**54**]. Backstitch evenly all round to turnings of brim and over the wire, and stitch up the join. Wire *inside* the top of sideband at the extreme edge.

The Tip. As no pattern is usually made for a hat tip, a piece of espatra, rather larger than required, is pinned on sideband (with the cross of espatra to the front of sideband), smooth side uppermost [**54**]. Cut off about 1 in. at the time to shape of sideband and wire, stitching it as you proceed. When the half is done, start again from the centre-front.

Shaping the Tip. Great care should be taken to keep the tip a good shape, and not to cut away too much, or it will sink in, and prevent the covering from setting well. Dome crowns [**24**] are bought blocked ready made.

Oval crowns with a dip in the centre [**25**] have the tip rubbed and stretched in the centre to make the necessary dip.

Oval crowns without dip are cut from two similar pieces, wired on one side, and the other sewn to it.

When a brim has to be gradually curved, as in a Gainsborough or San Toy, the shape should be held on the arm, or some other soft substance, and the espatra gently rubbed with a thimble. Rub on the outside for an upward, on the underneath for a downward curve.

For a boat shape, in wiring the edge of brim the shape is slightly contracted.

For fluted brims the edge is slightly stretched in the wiring.

In shapes with crowns larger at the top than at the base, the crown is not sewn on until the upper brim is covered [**40**].

In some shapes with deep sidebands the brim is slipped over the crown, part of the sideband making the bandeau [**53**].

Bonnet shapes are made up in the same way as hat shapes, except that the outside wire must go all round, overlapping for 2 in. at the back. Cut the tip exactly to pattern, and the sideband with ⅜ in. turnings round the bottom. Cut the front or brim with ½ in. turnings round the head, snicking the turnings at regular intervals, and folding them back to the edge of pattern to define the headline distinctly.

Wire-stitch a wire round the outside of these snicks as for hat, leaving ½ in. of wire beyond each end. Pin the bottom of sideband round the headline of the front, beginning from the centre-front, and snick the ⅜ in. turning to make it set well. Then backstitch this round.

Wire the top edge of sideband inside, leaving ½ in. of wire at each side. Pin the tip round the top of sideband, and wire-stitch it on carefully.

Wire the edge all round, nipping on the ½ in. turnings left at the ends of the sideband and headline. Wire-stitch it across the back, overlapping the wire for 2 in. where they meet, and cut away any rough turnings that may be left inside.

To enlarge a bonnet shape, cut the pattern in the middle, leaving the sides the same shape, and add 1 in. or 2 in. in the centre of shape. If the sideband is also enlarged, it will make the whole band wider.

Mulling. Mulling is the process of covering the wires with mull muslin to prevent the wire and stitches marking the material. Cut strips of mull muslin on the cross, or sarcenet about 1 in. wide, turn in the edges, bind round the edge of brim and tip, using the long backstitch [**55**].

Mulling the tip must be done by two processes: first sew round the tip, and then round the sideband. It will not set well if the stitches are taken through both edges alternately.

For shapes to be covered with silk, crêpe, thin velvet, or similar light millinery material, both upper and under brim and entire crown are covered with mull cut to shape, and the edges mulled as described above. Often the under brim only is mulled all over, in which case the wire ½ in. from edge of brim is omitted.

Hat shapes built up in this way are lighter in weight than shapes that are made entirely of wire. Espatra, further, lends itself more readily than wire to manipulation where a soft effect is needed. Wire shapes, on the other hand, are firmer, and, if carefully handled, will keep their shape much longer. These are dealt with in the next chapter.

ANTOINETTE MEELBOOM

Autogenous Welding. Air-hydrogen, Oxy-hydrogen and Oxy-acetylene Blowpipes. The Use of Thermit. Hard and Soft Solders.

WELDING AND SOLDERING

In the manipulation of metals it is essential that there should be simple and efficient methods of uniting two pieces of the same or different metals, and there are many processes for making such unions. The ideal method is by *welding*—that is, by fusing, or almost fusing, the edges of the metals to be united, usually by the heat of a coke fire, and by hammering the edges until the opposing surfaces become merged into each other, making a homogeneous and strong union. In making a weld—with two pieces of wrought iron, for instance—the finished work may be as strong as if it had originally been rolled in one piece; and if a subsequent rupture takes place, it is as likely to be at some other spot as at the weld. But many metals—such as cast iron, many steels, zinc, brass, etc.—cannot be welded by the simple process described, and some cannot be welded at all. In cases where the temperature of the coal or coke fire cannot raise the metal to a temperature sufficiently high to permit welding by the time-honoured method of heating in the fire or blowpipe, the process of electric welding may be employed, and is extensively employed in welding steel. The air-hydrogen blowpipe—that is, a blowpipe the gas of whose flame is a mixture of air and hydrogen—is also used in the process known as "burning" or autogenous soldering or welding. Now the oxy-hydrogen and the oxy-acetylene blowpipes are employed for the same purpose. The wonderful *thermit* process introduced a few years ago is also of great industrial importance, and by its agency welds in difficult positions are easily and economically made. It takes advantage of the great affinity of aluminium in the form of powder for oxygen and the very high temperature attained during the process of chemical union. All these processes we shall consider at some length.

Soldering. But in addition to the various welding processes there are the processes of soldering, which may be divided into two classes—hard soldering and soft soldering. The value of soft soldering compared with welding is that it may be used without necessarily spoiling the appearance of the surfaces being united. In soldering, the two surfaces to be joined are not raised to the point of fusion. Union is attained by the use of a third substance—the *solder*—an alloy with a lower melting point than the metal being joined, which, by the help of a *flux*, is made to flow over the surfaces to be placed into contact, so effecting union. Soft soldering does not give such an intimate union as welding, but it is sufficiently strong for very many purposes. Ordinary tinware is invariably soft soldered. The process is the only one that would permit the tin-coated iron surface to retain its finished appearance.

Hard soldering, on the other hand, uses alloys of a much higher melting point than the soft solders, and the unions are therefore stronger. These hard solders are usually termed in the trade "spelter" or "brazing spelter." The name should not be confounded with the word "spelter" used as a synonym for ingot zinc.

We do not include in the processes of uniting metals the mechanical one of riveting, which scarcely falls into the classes of work we set out to consider.

Welding. Welding is possible with those metals which, as they are raised under the influence of heat from cold to the fused or molten state, pass through a pasty or plastic stage. This plastic stage is the welding heat. The ends of two bars of iron may be heated to this welding heat, placed in contact and hammered, and the result is a weld. The ends may be sloped or upset; or one may be split and the other pointed, so as to give greater chance of a good weld. The process is described in SMITH'S WORK. The necessary conditions for a good weld are that the welding surfaces should be as large as possible—hence the sloping, upsetting, or splitting—that there should be no scale or oxide, and that the heat should be sufficiently high. To remove any scale that may exist, welding powders, so-called, are frequently thrown upon the surfaces to be united. The most frequently used powders are boric or boracic acid and silica or sand. The effect of these powders is to form with the scale a slag, which fuses readily, and does not therefore interfere with the process of welding.

No weld is possible with cast iron or steel, the carbon content of which exceeds 2 per cent., as these metals pass quickly from the solid to the molten state and have no plastic stage to give them a possible "welding heat."

Welding Steel. Iron is welded at white heat or a high red heat, but steel must be welded at a lower heat — in fact, the heat of the latter should never be raised higher than the degree necessary to effect a weld, or the quality of the metal is impaired. At the beginning of a steel weld the pieces should be struck lightly, and only after the weld has gone a little way should the sledge-hammer or the power-hammer be used. Steel must be worked quickly on account of the low heat at which the work must be done, and even then it may be necessary to give it more than one heating. The article welded must be annealed after welding—that is, it must be heated slowly to welding heat, and allowed to cool gradually. After being heated, the article may be covered with dry, warm sand, or may be left in the forge until the fire is cold, either method giving the necessary time for cooling; but, of course, the latter is impracticable if the fire is in constant use.

The fuel in heating cast steel for welding purposes should be coke or breeze, and not coal. The steel should be heated quickly, being meantime covered from the air. The welding heat is low, and the metal should not be overheated. Before putting it into the fire, a flux composed of equal parts of borax and washing soda and a little white glass which has been fused together and afterwards ground, should be sprinkled over it, which will dissipate the oxide that may form. Many other fluxes besides that mentioned may be used. One authority recommends a mixture of sulphur,

sal ammoniac, and borax in the proportions of 1, 2, and 10 respectively; while another uses powdered white marble.

In welding cast steel to iron the latter must be raised to a much higher heat than the former. Usually a flux different from that mentioned above is employed. It generally contains a percentage of prussiate of potash with borax and sal-ammoniac. An extensively used French process of welding—the Lafitte—uses plates made of wire gauze covered with the fluxing powder.

Welding Copper and Platinum. Copper for welding is usually heated under the blowpipe instead of in a fire, for the carbon of the fuel would unite with the metal and form copper phosphide, making a solid weld impossible. Copper, particularly at its welding heat, is very soft, and requires careful manipulation, as it does not offer the resistance to blows that iron does. The flux should be applied before the metal is at the proper cherry-red welding heat. It usually consists of soda phosphate and boracic acid in the proportions of 1 and 2.

It is possible, but difficult, to weld platinum, because this metal gives off its heat so rapidly that the heated edges scarcely remain at a welding temperature long enough for the operation. To make an efficient platinum weld it is necessary to have the hydrogen blowpipe playing upon the surfaces during the entire operation. No welding powders are used for platinum.

Autogenous Soldering, or Burning. The process of autogenous soldering, or *burning*, as it is commonly termed, consists in uniting two pieces of the same metal or of different metals by fusing the edges to be joined, and thereby causing them to run together so as to form a strong union. It is more akin to welding than to soldering proper, hence we give it consideration before passing on to discuss the subject of soldering. It makes a much stronger and more intimate union than soldering. No interposing metal is used, hence the expansion and contraction of the finished joint is uniform, and rupture is not likely to take place under any strain insufficient to rupture the solid metal. In soldering, also, the interposed solder is apt to oxidise more or less than the joint, thereby causing weakness: autogenous soldering is free from this objection.

The heat used in autogenous soldering must be intense enough to fuse the metals being operated on. Hence, until recently it has been only the metals with comparatively low melting points that have been "burned" with the help of the blowpipe. But during recent years the oxy-hydrogen blowpipe and the oxy-acetylene blowpipe have been pressed into service for autogenous soldering, so that now even iron, steel and nickel can be successfully joined by burning. We shall consider these improvements in the process when we have discussed its older applications.

We must recognise two classes of autogenous soldering. In one, molten metal the same as that being joined is poured over the edges desired to be joined. It unites with these edges and forms, if thoroughly successful, a homogeneous mass with the work upon which it has been poured. We have seen this process already in the treatment of brass castings which are required in one piece, but are, for foundry convenience, or because of the limited sizes of moulding boxes, cast in two or more pieces [see page 1726]. The process is also used for iron castings, small pieces that have broken off a large casting being renewed by this means, or faulty parts of a large casting being intentionally removed and renewed by pouring molten cast iron around the part, placed in a suitable mould. In these cases the essentials to good work are a properly prepared mould, in which the work is placed, and into which the molten metal may be poured, a high degree of fluidity in the pouring metal, and provision that the first part of the pouring may run out by suitable gates after passing over and heating the surface. Thus, the cold surface is thoroughly heated before the later part of the pouring reaches it; the union by this means is more certain, and stronger. To attempt to use the first part of the pouring before the cold surface had been raised to the point of fusion or semi-fusion would result in a chill.

Pewter and Lead Burning. Pewter work is usually united at the corners by autogenous soldering, especially if the piece be of such a shape as to make soldering from the inside impossible. A small piece of pewter of suitable shape is laid upon the part where the union is to be, and heat is applied with a copper soldering bolt, which is passed over the work until the joint is properly made. The work is then filed and polished. If it has been properly done no joint is visible, and the corner looks as if it had been made from the solid. The heat may be applied by means of a blowpipe instead of with the soldering bolt.

Lead burning is the most common application of autogenous soldering. For lead tanks and lead vessels used in chemical works "burning" is the only proper method of making a joint. The lead to be burned must be scraped clean. For some work, such as lead roofing [see PLUMBING], it is sufficient that the two edges to be joined overlap a little; but for strong seams, such as are required in the bottom of acid tanks, strips of clean lead are placed above the two butted edges it is desired to join, and the heat, when applied, causes the new piece to fuse on to the top of the other two above the butt. The heat may be applied with a plumber's lamp, or by a blowpipe burning service gas, but the best and usually most convenient method is by a "burning machine" or hydrogen gas generator. This is an apparatus consisting of a lead cistern, into which zinc cuttings are put with diluted sulphuric acid so that hydrogen is evolved, and after passing through a water chamber to be purified is led into an air vessel, which is merely a barrel containing an inverted circular tank of zinc floating on water. A suitable pipe is led from this tank, and by applying a weight to the top of the floating tank or gas bell, the hydrogen is given pressure to send it with the required force through the blowpipe, which is connected to the end of the pipe.

Lead burning may have to be done in work in a horizontal position, working from the top. It may have to be done upon lead in a vertical position, which is much more difficult. It may, finally, have to be done overhead, and this is naturally the most difficult of all. The method pursued may be divided into two classes: surface fusion, which is comparatively simple, and through and through fusion. Lead oxidises rapidly, especially when hot, and oxidised edges cannot be joined so as to give a perfect seam. The outside flame of the blowpipe is an oxidising flame, and the point of the inner flame, which is the point of greatest heat, should be applied to the spot it is desired to fuse. The blowpipe should be brought sharply into position and withdrawn sharply, so that the external flame may not linger upon the lead that is fused or in process of fusion. Some lead burners claim to be able to run down a seam without

withdrawing the flame, but this is neither the usual nor the safest practice. Intermittent fusion is better. Select a point of the work and apply the flame to it until a circle of semi-fusion is made. Then withdraw the flame for a moment and select another point a quarter of an inch along the seam on which to operate. With heavy lead—say over 6 lb. —the seam must be attacked on both sides to make first-class work. When the position of the work makes this impossible, the two edges to be joined should be butted and the edges should be scraped so as to form a V-shaped joint, with the apex of the V where the edges touch. A strip of lead should now be burned on to the recess, the surfaces meanwhile being kept clean by scraping with a shave-hook.

Care should be taken to get a flame of the proper shape. It should be regular, each side of it being the shape of a true arc drawn from the point of issue from the blowpipe to the tip. An irregular flame splutters out in the shape of a horse's tail and has no true point. The proper shape of flame can be got only with practice, and by making the pressure and quantity of both gas and blast proportionate, so as to give the best results.

The Blowpipe. We may consider the blowpipe. It is essentially, in the case we have been considering, an apparatus consisting of an inner or central brass tube, and an outer brass tube encompassing the inner one. The inner tube is connected to the gas supply, in this case the hydrogen generator. The outer tube is connected to an air blast, usually either a fan or foot bellows. The gas coming from the inner tube is ignited, and by causing a blast to issue from the larger and surrounding orifice the flame is directed upon any piece of work to which it is desired to apply heat. The principle is the same whether the fuel be hydrogen, coal gas, oxy-hydrogen gas, or oxy-acetylene gas, the gases in the case of the two last-mentioned being mixed in the blowpipe. The hottest part of the flame is the point of the inner or blue flame, and for work to which it is desired to apply the greatest possible heat the blowpipe is held so that the part of the flame mentioned may impinge upon the work. Most blowpipes have a spring device by which the blast passing up the blowpipe may be regulated in accordance with the requirements of the work.

For small work an ordinary mouth blowpipe is used, and jewellers invariably use such a blowpipe. The heat is the flame of a spirit lamp, and the tip of the blowpipe is inserted into this flame, and the workman, with cheeks distended, blows through the blowpipe, meantime holding the article to which he is applying the heat in the proper position that the flame may be blown upon it. In such cases the article is usually put upon a block of charcoal. An efficient blowpipe device may be made by anyone with a penny candle and the stem of a clay pipe.

Oxy-hydrogen Blowpipe Welding. One difficulty long stood in the way of oxy-hydrogen blowpipe welding—the lack of any known method of producing the gases at economical cost. This difficulty has been overcome by a process recently introduced by Messrs. Braby & Co., of London and Glasgow. The advantages of the oxy-hydrogen flame over the electric arc for welding purposes are that it is under complete control, and that it is not liable to alter the carbon proportion of the steel being welded. The decomposition of water by electrolysis is obviously the most simple manner of securing the two gases, and the apparatus used does this effectively at low cost. Two problems had to be solved in designing the apparatus—the selection of the best material for the electrode plates and some manner of collecting the gases apart. The tank used is 6 ft. long and 18 in. deep, its sides being only 1½ in. apart. A vertical plate of iron is placed the whole length of the thin tank so as to keep the gases apart as they are generated; this plate has a rectangular aperture so as to permit the flow of the electrolyte. The opening at top of the tank is closed with two rubber blocks, which rest between the centre plate and the sides. The sides of the tank are of iron and form the anode and cathode. To the water in the tank is added soda, which liberates sodium and hydrogen at the cathode side and oxygen at the anode side. The sodium, as soon as liberated, decomposes the water in its vicinity, thereby increasing the delivery of hydrogen at the cathode. Water is added continuously by means of a pipe at the bottom of the tank and the gases are led off separately from the top, passing through a 3 ft. water seal, into the gas holders, where they are stored. In each gas pipe a piece of platinum is kept red hot by electric current, and this provision removes any traces of oxygen from the hydrogen and any hydrogen from the oxygen. At Messrs. Braby's works the current is 200 amperes at 70 volts, and passes through thirty vats in series. The blowpipe, where the gases are burned, is a conical mixed jet pipe with a small brass nozzle. The work done with the oxy-hydrogen blowpipe includes the autogenous soldering of all kinds of sheet iron work and general repair work of all kinds. The process is used for iron, steel, brass, copper and other metals. One metal may be fused to another by its means. Oxygen and hydrogen are used in the apparatus in the proportion of one to six respectively, and as the decomposition process yields the two gases in the proportion of one to two, there is excess of oxygen, which is compressed into cylinders and sold for medical and other purposes.

In autogenous soldering of iron and steel by the oxy-hydrogen or oxy-coal-gas, difficulty is experienced owing to the oxidation of the iron by the steam produced in the flame. A French precaution to avoid this oxidation consists in the addition to the coal-gas or hydrogen of a hydrocarbon rich in carbon, substances such as acetylene or the vapour of light petroleum being used. It is claimed that by this means the products of combustion contain less steam and more carbon dioxide; also that the latter is partly dissociated with formation of carbon monoxide, which has a reducing action, and thus prevents oxidation of the iron.

Oxy-acetylene Welding. The use of oxygen and acetylene in a special blowpipe for supplying the heat necessary in autogenous welding is a recent development and has many advantages. Pioneers in the manufacture of apparatus for this work are the Thorn and Hoddle Acetylene Company, of London. The oxygen is contained in a cylinder, where it has been compressed to 120 atmospheres. The acetylene is generated in an "incanto" generator, and after passing through a purifying apparatus is led into a gas-holder, where it is retained under a pressure of 6 in. of water. With the oxy-acetylene blowpipe it is found, in practice, that the best welding results are obtained by a mixture of 1 volume of acetylene with 1·7 volumes of oxygen. The flame produced has in its centre a small white cone, at the apex of which the temperature is about 6,300° F. This flame consists almost entirely of carbon monoxide,

which is being converted at its extremity into carbon dioxide. Round the flame is a relatively cool jacket of hydrogen, which, not being able to combine with oxygen at the very high temperature in the immediate neighbourhood of the flame, remains temporarily in the free state, and thus protects the inner zone from loss of heat while excluding the possibility of oxidation, which is a difficulty other methods of welding have to contend with.

The heat, in addition to being greater than that obtained by any other blowpipe system, is also more concentrated. The gases are mixed in the injector chamber before they issue from the nozzle of the blowpipe. Work with this blowpipe is rapid. A good workman can make a weld of 15 ft. per hour, working on a $\frac{1}{4}$-in. steel plate, or of 6 in. per hour on a $\frac{1}{2}$ in. steel plate. Oxy-acetylene autogenous welding has been successfully applied to a wide variety of work, such as cycle parts, welded boilers, steel safes, tanks, tubes, and all classes of copper work.

Aluminothermy. The introduction of aluminothermy in the process of welding or autogenous soldering a few years ago attracted more attention than any other process in the same department of industry for many decades. It ranks in importance with electric welding, and is much wider in its application. A brief introduction is necessary to enable the basic principle of the process to be understood. All chemical reactions are accompanied by the absorption or the liberation of heat. Mix sulphuric acid and water and observe that considerable heat is evolved; indeed, the heat may be so great as to cause an explosion, and it is much safer to add the sulphuric acid gradually to the water. The manufacture of aluminium from the oxide demands great heat and the commercially successful process of making aluminium is by the electric furnace [see page 1459]. This heat, or a great part of it, is absorbed by the metal, and becomes latent heat, which may be given off again if the proper method of causing this liberation of heat is known. It was the discovery of the method of achieving this end that brought aluminothermy into the realm of everyday industrial processes.

Oxide of aluminium is formed with very great heat, but the oxidation of aluminium at ordinary temperatures is negligible. If, however, the oxidation is started at a sufficiently high temperature, it will proceed rapidly until the whole mass of metal is reached. This reaction depends upon the fact that aluminium gives out very great heat as it combines with oxygen, for which its affinity is very great. So great is this affinity that the metal will reduce all other metallic oxides to their metals.

Thermit. In practice, the material used in aluminothermy is a compound sold under the proprietary name of *thermit*, and is made and sold by Thermit, Ltd., of London.

It is a compound of finely divided aluminium and a metallic oxide, usually oxide of iron. The heat evolved is so great—it exceeds even that of the electric arc—that special crucibles and special methods are necessary in the practice of aluminothermy. The crucible usually has the shape of an inverted cone, and is made of iron sheet with a magnesia lining, and a sheet-iron hood, which prevents sputtering during the reaction. The bottom —that is, the apex of the inverted cone—has a round hole into which is fitted a tapping bar, which is merely a short iron rod. Above this tapping bar is placed a sheet-iron disc made to fit the bottom of the crucible, and above the disc is placed a piece of asbestos with some fireproof material tamped in above it.

The thermit is placed in the crucible, into which the tapping bar has been fitted as described, and the mass is ignited by the use of a special ignition powder. Then the reaction begins, and proceeds rapidly until the aluminium is burned to aluminium oxide, and the iron remains in the pure state, being in reality a very low carbon steel, usually with about ·1 per cent. of carbon. Then the reaction subsides, and with a rod the tapping bar is dislodged upwards and pushed into the intensely hot body of molten iron, where it is instantly reduced and incorporated. The mass flows out through the tapping hole into the mould prepared for it, where it settles upon the surfaces it is desired to weld or unite.

Uses of Thermit. The most frequent use to which thermit has been put is in the welding of tramway rails. It welds rail end to rail end so that the whole rail system of a tramway service may be welded into one entire length of rail. It is possible to follow this practice for tramway rails where the rails are bound into position by paving blocks, but for the permanent way of our railways, where the rails have no such binding, welding is impracticable on account of the bending that would ensue when the rails were elongated by heat.

There are many other uses for thermit. They lie chiefly in foundry practice, for burning castings together or for renewing faulty parts of castings. In marine repair work the process has saved many thousands of pounds, as by its means a shaft or other piece of marine engine mechanism may be repaired at once, and so enable the vessel to put to sea, or proceed without the delay that would be caused by the older method of making a duplicate part.

Crucibles and Moulds. Several other considerations may be mentioned before we leave the subject of thermit welding. The crucible we have described is tapped from the bottom by the method described. The use of such a crucible is imperative, because lip pouring is impossible. The slag which forms upon the top adheres to anything which it may touch, and if a little slag entered with the poured metal it would prevent proper adhesion and spoil the work. The mould must be made so that the first part of the metal will run to waste, heating the parts to be united before it does so. Also the moulds must be made as for high-grade steel castings, and the faces finished with a wash of silica, or of silica and plumbago. They must be thoroughly dried, and slowly heated to red heat so as to make them quite free from moisture. The thermit must not be poured at too high a temperature. It is usual to allow the heat to subside a little after the reaction has ceased, and it is also customary to throw into the crucible some soft steel punchings and to permit these to melt before tapping.

We have described only a small part of the field in which thermit is used. For the rest we must be content with mentioning a few of its applications without detailed description. In steel castings, thermit may be placed in the riser, the heat of the molten steel being sufficient to ignite it. It raises the temperature of the pouring, enabling smaller risers to be used, and keeping them open longer. The same process is sometimes used for cast iron, but as the heat of cast iron is not high enough to start the reaction, some ignition powder

must be placed along with the thermit. It is also introduced into steel castings to prevent "piping"—that is, the formation of a large shrink hole near the top of the casting. In such a case the thermit is introduced just before the casting becomes solid; it makes the steel more fluid again, and permits the gas to escape before final solidification.

Electric Welding. The process of electric welding permits welding to be applied to the union of many metals which could not be united by the ordinary process of welding as already described. Given the proper appliances, the operation of electric welding does not require the high skill born of long practice that ordinary welding demands. The intelligence has been put into the machine, and man's part becomes to an equivalent extent mechanical. The work is secured in clamps, through which the current passes, the surfaces to be joined being opposed to each other. As at the point of contact there is more resistance than there is through the solid metal, heating takes place, and as the metal becomes soft the clamps are made to exert pressure towards each other, and the weld is made by this pressure. The Thomson process of electric welding is that usually followed, and the makers of the machines for this process are the Electric Welding Company, Ltd., of London.

In electric welding it is desirable that there should be a good deal of work of one class, because the machines are limited in the scope for which they are fitted. The power required to raise the metal to welding heat is very great during the time it is called into action, and the machines are graded by the cross sectional areas they can undertake and the horse-power of the generator. Thus only work of approximately the same sectional area is suitable for one machine. Angle iron could not be welded on a machine for wire, for instance.

Sometimes the electric currents used are as high as 50,000 amperes; but the electromotive force is only half a volt, so that little danger attaches to their use. Alternating-current generators are used, and if a direct current only be available a motor alternator must be installed.

The weld begins in the centre and extends towards the surface as the temperature rises. The resistance of the hot metal, being higher than that of the cold metal, draws the heat to the desired parts. When the welding heat has been reached, the ends are pressed together as already stated. The pressure is given either by manual or hydraulic power. The machines have been developed very much in the direction of making them automatic.

Value of Electric Welding. The quality of the work done by electric welding is more likely to be excellent than work performed by hand welding. From the point of view of economy, the former has everything in its favour when output is large. Its sphere, however, does not lie in small or in general work, but in repetition work. The economy secured by electric welding is caused largely by the absence of special preparation of the work—such as sloping, upsetting, and splitting—which often make a union demanding a somewhat lengthy drawing out and finishing. Work for which electric welding is specially suited includes chain manufacture, cycle components, carriage work, and tools such as axes, where the poll of mild steel is electrically welded to a tool steel edge. The speed with which the work can be carried out is surprising. Tests made show that iron and steel pieces of 4-in. sectional area can be welded in 90 seconds with a horse-power expenditure of 83·8, and a copper weld of 1-in. sectional area takes 23 seconds, with almost the same horse-power expenditure. An additional value of the process lies in the fact that dissimilar metals can be united by its agency. Iron, wrought or cast, can be welded to zinc or copper, for instance.

Soft Soldering. Soft solders melt at comparatively low temperatures. It is possible to use them with nearly all metals. In the operation of soldering there are three necessities: the means of applying the heat sufficient to fuse the solder, the solder itself, and the flux, which enables the solder to associate itself intimately with the metal or metals to which it is applied. The further apart the melting points, the hardness, and the malleability of the solder and of the metals being soldered are, the weaker is the union. Thus, a soft soldered joint in iron, brass and copper is always comparatively weak. It may have some strength if the metals joined by soldering are comparatively thin, so that they can bend under any stress to which the joint may be subjected, thereby relieving the solder of the duty of resistance; but if the metals be heavy and inflexible a blow or other act of violence may cause disruption of the union. Soft solder, again, having properties not far removed from those of tin and lead, makes a strong union with these metals, which, when soft soldered, may be hammered and worked with comparative freedom. This point has much to do with deciding the method of soldering to be adopted in any particular case.

In soft soldering the usual way of applying the heat is by means of the tool known as the *soldering iron, soldering bolt* or *soldering bit* [see PLUMBING]. This tool is a short, square bar of solid copper drawn to a point and mounted on an iron rod, which is provided with a handle. Its point must be covered with tin before being used. To tin it, it is heated in a stove or fire of any sort until it is dull red; it is then filed slightly so as to clean the point, and is rubbed first against a piece of sal ammoniac and then upon some solder placed upon a copper or tin plate. It is then ready for use. In the actual operation of soft soldering the surfaces to be united are first cleaned if necessary—diluted hydrochloric acid applied with a brush or cloth is usually employed—then the flux is applied to the surfaces, and finally, the hot soldering bit, after being rubbed against the solder so as to take on a small quantity, is rubbed over the flux and the joint is made. The flux and the solder may vary in composition and depend upon the nature of the metals being soldered. We shall consider them presently.

Soft soldering is often done by means of a blowpipe instead of a soldering bolt, particularly by gasfitters and pewterers. A plumber's soldering lamp may be used, or expert workmen may burn some rushes or wood chips around where the joint is to be made, directing the flame by means of a blowpipe. The flux is, of course, used as with the soldering bolt. Gasfitters use a solder rich in tin and a flux made of oil and resin mixed in equal proportions. Pewterers use a solder containing bismuth, which is more easily fused than most soft solders, and as flux they employ Gallipoli oil, which is a green olive oil.

Soft Solders. The most commonly used soft solder consists of one part of lead to two parts of tin. "Plumbers' sealed solder," so-called, is two parts of lead to one part of tin, and is fusible at a considerably lower melting point [see page 1457]. The solder consisting only of lead and tin, and

having the lowest fusibility contains three parts of tin to two parts of lead. A more fusible solder can be made, however, by introducing bismuth. By increasing the percentage of lead and decreasing the percentage of tin the solder becomes cheaper. Bismuth adds considerably to the cost of a solder.

The composition first mentioned—two of tin to one of lead—is used for lead and tin pipes, Britannia metal, copper, brass and other copper alloys, and iron and steel. The flux used may vary with different metals, and we shall consider this point in discussing fluxes.

It cannot be alleged that there is uniformity in the composition of solders for various metals, many makers having preferences for formulas that others find unsuitable. Different experiences give different results as the strength and nature of the fluxes used differ. But in spite of this the following table, which shows solder compositions used in many shops, may not be without value. To avoid repetition we include hard solders in the table [see also next page].

COMPOSITION OF SOLDERS

Purpose.	Composition.								Flux.
	Tin.	Lead.	Copper.	Brass.	Zinc.	Silver.	Gold.	Bismuth.	
Plumber's ordinary	1	3	..	..	..	..	..	..	Resin.
„ sealed ..	1	2	..	..	..	..	..	..	„
„ fine	1	1	..	..	..	..	..	..	„
Tinman's solder ..	3	2	..	..	..	..	..	..	Resin or zinc chloride.
„ fine......	2	1	..	..	..	..	..	..	„
Hard solder for iron, copper, and brass	..	..	2	..	1	..	..	..	Borax.
Spelter solder......	..	..	1	..	1	..	..	..	„
„ but more fusible ..	..	..	1	..	1	..	..	..	„
Pewterer's solder ..	3	4	..	..	..	..	..	..	Resin or zinc chloride.
Bismuth solder	1	1	..	..	..	..	..	1	„
For gold	..	..	4	..	..	2	12	..	Borax.
„ another	..	..	1	..	..	2	24	..	„
For steel	..	..	3	..	1	19	..	..	„
For aluminium-bronze..........	..	..	1	..	..	4	..	..	„
For silver	..	..	1	1	..	19	..	..	
Fusible solder for meat tins	16	10	..	..	..	..	..	1	Resin.

In this table the solders of which borax is given as the flux are hard solders, and those of which resin or chloride of zinc is the flux are soft solders.

Manufacturing Soft Solder. Soft solder should be made in a porcelain or stone vessel, because in an iron pot the solder may absorb some of the iron. First melt the tin and then add the lead gradually in small pieces, stirring with a wooden stick. When the whole is fused and thoroughly mixed the alloy is poured into moulds, usually short bars about 8 in. long, from ½ in. to 1 in. broad, and from ¼ in. to ½ in. thick. Suitable moulds may be made by taking a mass of clay, beating its top flat and pressing into it in various places a stick of solder, thus making depressions into which the new solder may be run.

Fluxes. Soldering fluxes are numerous. The plumber uses both resin and chloride of zinc. For electrical work chloride of zinc is frequently forbidden, but is still used to a fair extent. For the meat canning industries, also, chloride of zinc is supposed to be harmful but is still greatly used, sometimes unknown to those who use it and who purchase chloride of zinc solution under a proprietary name. To make chloride of zinc solution, or *killed spirits*, as it is called, dissolve zinc in hydrochloric acid, or spirit of salt, as it is commonly termed, putting in more zinc than the acid will dissolve, so that the solution may be saturated. The ebullition may be too violent with pure hydrochloric acid, and water up to two parts to one part of acid may be added. The zinc should lie in the acid for at least twenty-four hours, when any excess of zinc may be removed, and the soldering liquid is ready. It is bad to use scrap zinc as it may contain iron, which is deleterious, and scrap zinc is always dirty. The solution may be filtered with advantage. Sometimes other substances, such as sal ammoniac or glycerin, are added in small proportions and are held to improve the fluid. This flux will suit nearly every purpose. For iron it requires to be stronger and may be used without water. For soldering galvanised iron—an extremely difficult operation and not a pleasant one—this flux would cause adhesion only to the zinc coating, and, therefore, raw spirit—that is, pure hydrochloric acid—is used to remove the zinc, after which the above mentioned solution may be used to solder to the iron. Tallow and other oils and fats are used to a fair extent as fluxes. Lard oil is used to solder aluminium with fair success, but the soldering of aluminium is a difficult matter, which we shall consider separately. Gallipoli oil is used by pewterers, as already mentioned.

For copper and sheet iron a flux frequently employed is powdered sal-ammoniac or an aqueous solution of it, followed by resin. Sometimes the powdered sal-ammoniac and resin are mixed before application. It is extremely difficult to solder zinc as it removes the tin from the soldering bit very quickly, making frequent retinning necessary.

Before passing from the subject of fluxes we may notice a few that are put forward as having specific merit, although they give no promise of deposing chloride of zinc as the all but universal flux. The proprietary fluxes sold under fancy names we leave alone; they are almost without exception solution of chloride of zinc prepared as we have described above.

A soldering paste is made by mixing chloride of tin with starch paste. A soldering fat is prepared by heating two parts each of olive oil and tallow and by adding one part of powdered colophony; then, after the mixture has been stirred and has boiled up and cooled, one part of a saturated aqueous solution of sal ammoniac is added. Phosphoric acid in solution with water or spirit is also used.

Soldering Without a Bit. By careful manipulation the operation of soft soldering may be performed without a soldering bit. A lamp or gas jet may be used to make the surfaces hot, the flux is then applied, followed by the solder, and with skill a successful joint is achieved. If two pieces of brass or copper be filed to fit each other, covered with a soldering fluid, and have a piece of tinfoil interposed, thereafter being heated over a gas jet or fire, a union will result, the tinfoil fusing and joining the two surfaces.

Hard Soldering. Hard soldering is the process of joining two metals or two pieces of the same metal by a solder that has almost as high a

melting point as the metals joined. The term *brazing* is generally applied to this kind of soldering. The heat of the copper soldering bit used in soft soldering is not sufficient for hard soldering. The work is sometimes done in an open fire such as a smith's forge, but the usual process is to raise the heat by a blowpipe, using gas as a fuel and applying the blast either by a power-driven fan or by hand or foot bellows. The most usual and convenient way, especially in small shops, is by the use of a brazing forge with pedal bellows. The workman can then use both hands in controlling the application of the heat. Sometimes the bellows are replaced by a rotary fan for supplying the air blast, and either method is satisfactory.

Sometimes, again, a plumber's lamp may be used, but this is not so satisfactory, as the heat cannot be raised so high as with gas, and good work is not so certain. Some large firms—such as cycle manufacturers—who have much and constant brazing work of one class, have the hard solder in a molten bath and dip the work into this bath. This process is unsurpassed for the quality of work produced, but it necessitates more finishing than is required by the blowpipe method, as the molten solder adheres to a larger area of the work than is necessary to make the brazed or hard-soldered joint.

Hard Solders. In the table already given appear some recipes for hard solders. Such solders are, for convenience, divided into three classes—brass solders, which are used with steel, iron, and copper; argentan solder, used for German silver; and gold and silver solders used for these metals. The common composition of solders of the first class is 8 parts of brass to 1 part of zinc. Refractoriness is increased by lowering the proportion of brass and adding tin. Thus, a composition with 6 parts of brass and 1 part each of tin and zinc is much used where a more refractory solder is desired, and this may be made still more refractory by adding 1 part of copper. By increasing the tin, the ductility decreases and the colour tends to grey. For work where the joint has to withstand bending stress, a high percentage of tin is to be avoided, as it causes brittleness.

Making Hard Solders. In making hard solders it is advisable to use brass instead of its constituent metals—zinc and copper—because the loss of zinc when fusing the metals separately is uncertain, and because by using brass already made this loss is minimised very much. Sheet brass is better than cast brass as an ingredient in hard solder, because the rolling has imparted to it a higher degree of homogeneity than is possessed by cast brass.

First melt the brass at a strong heat, and in another crucible melt the zinc that is being added as such, also at a strong heat. Pour the molten zinc into the molten brass and stir the mixture well. Then the solder is ready to be poured, and there are several ways of doing this, the object of all being to obtain a fine granular product suitable for soldering. Sometimes the molten alloy is poured through a wet broom into cold water, this separating the metal into the granular particles desired. A better method requires a cistern placed so as to give a good head of water, and an orifice that projects a stream of water horizontally over a water-tank. The molten alloy is poured on to this horizontal jet of water, which divides it, and the grains fall to the bottom of the tank, whence they must be taken and dried before they have time to oxidise. By varying the strength of the water-jet and of the metal-pouring, it is possible by this method to make grains approximately of any desired size.

Argentan solder is used for German silver, and also for steel and other work, the joints of which are required to be very solid. A readily fusible argentan solder is made of copper 35 parts, zinc 57 parts, and nickel 8 parts. A more refractory composition contains copper 38 parts, zinc 50 parts, and nickel 12 parts (Brannt). A general rule is that the higher the percentage of nickel in the German silver to be soldered, the higher is the proportion of nickel in the solder. The composition is cast in thin plates, which are broken and beaten in a heated iron mortar, so as to make them into a powder. If it is found to powder easily, it has too much zinc, and if the operation is too difficult, it is deficient in that metal; if it shows either fault, it must be remelted and the fault remedied.

Gold and silver solders are used chiefly for soldering these metals, but are also used for articles to be enamelled, for bronze, cast-iron, etc., but on account of their expense their use is naturally limited to work of a high-class nature. A few recipes for these have been given.

Fluxes for Hard Solders. The most generally used flux for hard solders is borax. The purpose of the flux is to remove the layer of oxide upon the surfaces it is desired to solder, and borax is the best all-round agent for this. It effects its purpose by reason of the excess of boracic acid which it contains dissolving the layer of oxide. For higher temperatures, finely powdered glass of a fusible nature may be used. For soldering copper, phosphate of soda or phosphate of ammonia may be employed. Quartz sand mixed with decomposed soda, or, for very high temperatures quartz sand alone, is satisfactory. For coarse work, turpentine or olive oil mixed with sal ammoniac is a good flux. A solution of carbonate of ammonia (saturated) is used for brass. A liquid flux, known as *hard soldering fluid*, is made by dissolving phosphoric acid in alcohol. Many other fluxes are employed with satisfactory results, preference attaching universally to no particular agent, even for the same metals. It is largely a matter of experience and individual liking.

Soldering Iron and Steel. All metals are not equally satisfactory under treatment by the ordinary processes of soldering, and special measures are often required. We shall review the best processes of treating such metals.

Cast iron is frequently considered unsatisfactory under any process of soldering, but it is not so. It is frequently desirable to solder cast iron, especially in altering cast-iron foundry patterns. For this purpose, soft soldering imparts all the strength necessary. The surfaces to be soldered must be polished bright. Then dip the surfaces into potash water, and upon withdrawal dip into clean water, after which apply quickly undiluted hydrochloric acid. Then sprinkle with powdered resin and solder with the bit in the usual way, using any soft solder, but for preference one made of equal parts of tin and lead. The operation must be performed quickly before the surfaces have time to dry. A more refractory soldered joint may be made with iron or steel, by using copper or brass as the soldering medium. The surfaces are first filed or polished bright, and are tied into position with wire. Then upon the joint place a thin strip of copper or brass. Cover the whole with a good layer of clay containing no sand, and place it near a fire that the clay may dry. Then put the part to be soldered under the blowpipe and raise it to white heat. This causes the clay to vitrify, thereby forming a flux. If the metal being soldered is iron, it is cooled in water,

but if steel, it is allowed to cool slowly. Then the clay is removed and the joint has only to be cleaned. When the soldering medium is a copper strip, it requires a stronger heat than a brass strip, and the latter is therefore more frequently used for soldering steel. For small pieces of iron, a silver solder—equal parts of silver and soft brass—may be used; it is used as foil, and, after annealing, is placed upon the surfaces to be soldered, borax being used as the flux, and the heat being applied with the blowpipe.

Some time ago some tests of hard solders on steel and iron were made at the National Physical Laboratory. Of five solders experimented with, the best was found to have the composition—copper, 63·19 per cent; zinc, 36·31 per cent.; and lead, ·65 per cent. A conclusion drawn from the tests was that the quality of solder improves with the copper percentage. The solder that stood the tests most satisfactorily had the highest proportion of copper, and was as stated above. At what point the improvement of quality ceases by increasing the copper—for, of course, there is such a point—was not determined.

A German patent (E. Herzog, 6th May, 1902) makes a soldering paste for cast iron by mixing pure steel or iron powder, free from oxides of iron, with stearin or paraffin oil, borax, and camphor. A suitable mixture is steel or iron powder 80—120; paraffin oil 10—30; borax 30—50; camphor 1—4. The parts to be joined are well cleaned, coated with the soldering paste, and after addition of borax and solder are heated to redness, usually under the blowpipe.

The work of soldering or brazing saws is a common operation with saw doctors, and it is essential with band-saws. File the two ends to be joined smooth and tapering, so that one overlaps the other some distance. Tie the ends together with wire, so that they will retain their proper position during the operation. Apply to the joint some borax, reduced to a cream by rubbing it with water on a slate. Now sprinkle some brazing spelter over the joint and apply the blowpipe heat, until it is seen that the spelter has run into the lap. Allow the work to cool gradually, and finish by filing.

Soldering Zinc, Brass, and Silver. In soldering zinc and galvanised iron, the soldering bit must be kept very hot, and the flux used is hydrochloric acid, undiluted, or diluted with only one third of its volume of water.

The soldering of brass is made more easy if the surface has been previously tinned. This is easily done. Clean the surface, apply borax paste, prepared as already indicated, and place upon this a piece of tinfoil. Heat until the tinfoil fuses and runs over the surface. The solder adheres uniformly and tenaciously to surfaces treated thus. A good solder for brass is a soft spelter—commonly called Bath metal solder—consisting of 21 parts of copper to 79 parts of zinc.

Brass and steel may be soldered together by first coating the steel with a solution of sulphate of copper, and then by soldering the two surfaces in the usual manner.

Silver is soldered with an alloy containing 19 parts of silver, 10 of brass, and 1 of copper. This is reduced to granular form by the process already described, or if for fine work is made into powders by filing it. The flux used is borax, which should be rubbed with water upon a slate or hard stone, so as to make a cream, which is applied to the two surfaces with a brush. The powdered solder is then applied between the pieces, and the work is laid upon a charcoal block, where the heat is applied with the blowpipe. When the union is made, an immersion in pickle removes the excess of borax, and the work is finished.

Soldering Aluminium. A fortune lies at the feet of any man who can find a simple and efficient method of soldering aluminium. Many attempts have been made, and workers in aluminium have had their hopes raised many times that the problem had been solved, only to be dashed again. No economical process of soldering aluminium has been proved to be permanently successful [see also page 1461]. The film that always lies on the surface of aluminium is an oxide that forms immediately the metal is exposed to the air. The oxide can, of course, be removed by filing, but a new film of oxide forms instantly upon the new surface created by the file. It has been found possible by ordinary soldering to make what appeared to be a satisfactory soldered joint with aluminium, but the lapse of a few months has always shown it to be otherwise, and the union has been found to be faulty. It is for this reason that commercial articles of aluminium are never, or almost never, sold with soldered joints. Usually the articles are cast or pressed and drawn from one piece of the metal, or if it is necessary to join one piece to another, or another metal to aluminium, riveting or screwing is the method employed. Still, we can indicate some of the solders used for aluminium when attempts are made to solder it. One solder is composed of 1 part of zinc to 4 parts of tin, and the flux recommended for it is made of 1 part each of tin chloride and zinc chloride, and 8 parts of stearic acid. Another worker professes to have achieved success with lard oil as a flux. The aluminium is usually heated with a blowpipe, and kept hot during the operation. The copper soldering bit is said to discolour the aluminium, and a nickel soldering bit is recommended. Other solders for aluminium contain that metal as a constituent. Horner, in the "Encyclopædia of Practical Engineering," gives the following recipes for aluminium solders:

1. Aluminium 2·38; zinc, 26·19; tin, 71·19; phosphorus, 0·24.
2. Aluminium, 6; copper, 4½; zinc, 89½.
3. Aluminium, 6; silver, 3; copper, 3; tin, 18; zinc, 9.
4. Bismuth, 6; tin, 94.

Soldering Metal to Glass. Glass may be soldered to metal by first coating the former with lead or with amalgam. The glass to be coated with lead is coated on one side with chalk and water, and after drying is placed clean side up, and fixed down in a special cast-iron tray, which is then placed in muffle surfaces and heated until the glass is at about 650° F., just above the melting point of lead. Then molten lead is poured over so as to cover the glass, and the tray is oscillated for some time. Then the lead is allowed to run off, and leaves a layer upon the exposed surface of the glass. This process is used in the manufacture of glass buttons, in order to allow the stems to be soldered to them.

Special dictionaries explaining technical terms and phrases appear at the end of the Self-Educator

Formation of Company. Capital. Shares. Prospectus. Allotment. Register of Members. Purchase of a Business.

A LIMITED COMPANY'S ACCOUNTS

A LARGE and constantly increasing proportion of the business of the country is carried on by what are known as limited companies. Indeed, it is scarcely an exaggeration to say that the giant strides made by our commerce in the last half century would not have been possible without the assistance derived by private enterprise from the co-operation of the small capitalist which has been secured by the wide facilities afforded by limited liability companies for investment at a rather higher rate of interest than that afforded by Trustee stocks and the like.

Firms and Limited Companies. Before we can proceed to deal with the accounts of limited companies, it is necessary that we should know something of what a limited company is. It has been seen that a partnership is a combination of two or more persons who have united their resources for the purpose of jointly carrying on a business for their common benefit. They are jointly and individually liable for the debts of the firm, and in the event of failure are bound to contribute to the full extent of their private property, if necessary, to discharge the firm's indebtedness to outside persons.

In the case of a limited company, the proprietors, who are called shareholders, are only liable to be called upon to pay the debts of the company to the extent of the amount they agreed to contribute when they first joined the concern. In other words, their liability is limited, and the extent of the limitation is fixed by the shareholders themselves when they determine to become members of the company.

Memorandum of Association. A company is a number of persons combined into one body by law, so that the company has a distinct personality apart from the persons who compose it. Every public company must consist of at least seven members, and every private company must have two members. All companies must be registered at Somerset House with the Registrar of Joint Stock Companies, and the first step to be taken is for at least seven persons in the case of a public company, and two persons in the case of a private company, to sign a document known as the memorandum of association, which must contain certain particulars. Those particulars are: (1) the full name of the company, in which "limited" must be the last word; (2) the part of the United Kingdom in which the registered office will be situated; (3) the objects of the company, which are stated very fully; (4) a statement that the liability of the members is limited; and (5) the amount of the capital of the company and the manner in which it is divided into shares. Each of the signatories to this document must agree to take at least one share in the company.

Articles of Association. With the memorandum it is usual to lodge a further document known as the articles of association, which contains the regulations for the carrying on of the company. The articles make provision for calls on shares, transfers of shares, meetings of the company, votes of members, accounts, audit, and winding up. If articles of association are not lodged, the company is regulated by a model set of articles provided by the Companies (Consolidation) Act, 1908.

It would manifestly be impossible for the business of a company to be conducted by the shareholders as a body, and the work is therefore delegated to a small number of persons who are called the directors. They are frequently appointed by the articles of association, which also define and regulate their powers, qualification, retirement, and so on.

The memorandum and the articles (if any), and a separate statement of the capital, have to be left with the registrar, together with a declaration, usually made by a solicitor, that all the requirements of the Companies (Consolidation) Act have been complied with. Certain stamp duties have to be paid, increasing with the amount of the capital, and if the documents are found to conform to the requirements of the law, the registrar issues a certificate that the company has been incorporated.

The Company's Capital. Mention has been made of the company's capital and of the shares into which it is divided. Both these terms require further explanation, for the word "capital" has several different meanings in connection with a company, according to the sense in which it is employed, and there are various kinds of shares, each having different rights. The capital which is named in the memorandum of association is known as the *nominal capital* of the company, and is the maximum amount of shares the company is allowed to issue. The amount of the shares which the company has actually issued to applicants is known as the *subscribed and issued capital.* The amount which the shareholders have been required to pay upon the shares issued is the *called-up capital,* and the amount received by the company on the shares is the *paid-up capital.*

Classes of Shares. The nominal capital of a company is divided into a number of parts of fixed amount called *shares,* each of which has a distinctive number given to it. When there is only one class of shares they are called ordinary shares. When the capital is divided into two classes, they are usually *preference* and *ordinary* shares, the former entitling the holders to participate in the profits of the undertaking to a certain fixed limit before any distribution is

made to the ordinary shareholders. The limit is fixed by way of a percentage upon the amount paid up on the shares, which are known as five per cent. or six per cent. preference shares, or as the case may be.

When the preference shares have received their percentage, the ordinary shareholders are entitled to the remainder of the profits, provided there are no other classes of shares ranking behind them. Distributions may be made to the shareholders only out of profits actually earned, and such distributions are called dividends. There is sometimes a further class of shares, entitled *founders'* or *deferred* shares, which are usually few in number, and entitle the holders to a fixed proportion of the profits remaining, after paying a dividend at a certain rate upon the ordinary shares—frequently ten per cent.

The Prospectus. Many companies are formed for the purpose of purchasing as going concerns businesses which have previously been carried on by firms or individuals, and in order that the money required to pay the purchase price may be obtained, an invitation is generally made to the public to take shares in the new company. The invitation is contained in a document known as a *prospectus*, which has to be filed with the registrar. If the company is a large one, the prospectus is advertised in the Press, as well as being circulated by post to probable investors. It sets out the object with which the company has been formed, and, for the purpose of enabling recipients to form an opinion of the prospects of future success, information is given as to the value of the property to be taken over and as to the profits which have been earned in the past by the old proprietors. This information is usually given in the shape of valuations by experts, and certificates of profits by public accountants.

The prospectus further states the manner in which the shares will have to be paid for, which is usually a certain amount per share on applying for them, another amount on allotment, and further sums at stated intervals, until the full amount of the share has been paid. Part of the full amount may be left to be called up by the directors as the business of the company may require. The names and addresses of the officers of the company are also given, including those of the directors, bankers, auditors, solicitors, brokers, and secretary. Certain other particulars have to be given to comply with the requirements of the Companies (Consolidation) Act; but although these are of the utmost importance from the legal point of view, they do not require further mention here.

Application and Allotment. Enclosed in the prospectus is a form of application for shares, which has to be filled in and signed by the intending investor. He then has to forward it to the company's bankers, with a remittance for the amount stated in the prospectus as being payable on the shares. The money will be retained by the banker, and the application form sent on by him to the company. The secretary makes a list of the applications, showing the number of shares applied for, and a meeting of the directors is held to consider them. It is necessary for the directors to state in the prospectus the number of shares which must be applied for before they will issue any to the public, or, as it is termed, go to allotment.

If application has been received for the minimum number of shares, the directors proceed to allot them to the applicants in accordance with their applications—*i.e.*, they pass a resolution apportioning to each applicant the number of shares for which he has applied. In order to make the allotment binding upon the shareholder, a notice called a letter of allotment is sent to each applicant, stating the terms upon which the allotment has been made, and requiring him to pay the further amount now due upon his shares. As the dates arrive upon which further instalments are payable, applications are made by the company to the shareholders for payment until either the full amount of the shares or the amount mentioned in the prospectus as payable within a given time has been called up.

Entries in the Company's Books. Having now described the machinery by which the capital of a limited company is brought into being, it is necessary to explain the entries requisite for recording the various transactions in the company's books. In the case of an individual there is, of course, no obligation from himself to the business to provide the money he actually puts in as capital, and if he decides, upon reflection, not to start the business or invest his money, he is not bound to do so.

But in the case of an applicant for shares, the position is different. As soon as the company has notified its acceptance of his offer to take shares, he becomes bound to the company for the full amount of the shares allotted to him. As we have seen, he may not have to pay the full amount at once, but the company has the right to call upon him to pay at some time, and he is at once a debtor for the amount payable on the shares in respect of the instalments due on application and allotment. Entries are therefore made, debiting the shareholders with the amount due from them on application and allotment, and crediting accounts opened in the general ledger, entitled application account and allotment account.

Opening the Capital Account. Separate accounts are not opened for each shareholder in the general ledger. A distinct book is kept for the accounts of the individual shareholders, which is entitled the share ledger, and is generally combined with another book which the company is required by law to keep—*viz.*, the register of members. The form of the combined book will be shown later; at present we will follow the entries to be made in the company's general accounts. Let us suppose that a company has received applications for, and has allotted, 1,000 shares of £10 each, upon which £1 per share is payable on application, £2 per share on allotment, and £2 per share one month after allotment, the remaining £5 per share not being required at present. The entries

necessary in the company's books are first passed through the journal preparatory to being recorded in the ledger, and would be as under:

June 1	Sundry Shareholders .. .. Dr.	1,000 0 0	
	To Application Account		1,000 0 0
	For £1 per share, payable on application, for 1,000 shares of £10 each		
June 7	Sundry Shareholders .. .. Dr.	2,000 0 0	
	To Allotment Account		2,000 0 0
	For amount payable on allotment for 1,000 shares at £2 per share		
July 7	Sundry Shareholders .. .. Dr.	2,000 0 0	
	To First Call Account		2,000 0 0
	For amount payable one month after allotment, on 1,000 shares at £2 per share		

The entries would be posted to accounts in the ledger in the usual way.

The company will have received the full amount of the application money through its bankers; we will assume further that all the allotment money has been received, and that £1,900 of the first call is also received. These amounts will be entered on the debit side of the cash book and posted to the credit side of the sundry shareholders' account. Entries are then made in the journal closing the application, allotment, and first call accounts by transferring the balances to an account called the share capital account, which is the true capital account of the company and remains open in the ledger throughout the company's existence.

As a result of these various journal and cash book entries the accounts in the ledger will appear as shown below.

The balance to the credit of the share capital account represents the amount for the time being called up on the shares, while the debit balance on the sundry shareholders' account is the amount unpaid in respect of the calls which have been made.

Register of Members and Share Ledger. It is now necessary to ascertain how the accounts of the individual shareholders are dealt with. As in the case of a private partnership, each proprietor has a capital account of his own, although, as a rule, the book in which the accounts are kept is treated as a statistical book and not as a book of account. It is found convenient to combine the register of members, containing certain particulars and which the company is required by law to keep, with the share ledger containing the cash account of each member in relation to his share holding. Every member is debited with the respective amounts payable on his shares and credited with all sums he pays in respect thereof. The register shows not only the number of shares he acquires and disposes of, but also their distinctive numbers. The totals of the amounts debited to the individual shareholders must naturally agree with the amounts debited to the sundry shareholders' account in the general ledger, and the totals of the sums credited as paid will agree with the credits on that account. This explanation will enable the reader to understand the entries appearing in the form shown on the next page.

Dr. SUNDRY SHAREHOLDERS' ACCOUNT Cr.

June 1	To Application Account..	1,000 0 0		By Cash (posted in daily or weekly totals from Cash Book)	1,000 0 0
June 7	,, Allotment Account ..	2,000 0 0		,, do. do. ..	2,000 0 0
July 7	,, First Call Account ..	2,000 0 0		,, do. do. ..	1,900 0 0

Dr. APPLICATION ACCOUNT Cr.

July 31	To Share Capital Account	1,000 0 0	June 1	By Sundry Shareholders..	1,000 0 0

Dr. ALLOTMENT ACCOUNT Cr.

July 31	To Share Capital Account	2,000 0 0	June 7	By Sundry Shareholders..	2,000 0 0

Dr. FIRST CALL ACCOUNT Cr.

July 31	To Share Capital Account	2,000 0 0	July 7	By Sundry Shareholders..	2,000 0 0

Dr. SHARE CAPITAL ACCOUNT Cr.

			July 31	By Application Account..	1,000 0 0
				,, Allotment ,, ..	2,000 0 0
				,, First Call ,, ..	2,000 0 0

REGISTER OF MEMBERS AND SHARE LEDGER

Name: John Smith. Occupation: Merchant. Date of becoming a member: 7th June, 1906.
Address: 100, New Street, Oldtown. Date of ceasing to be a member:

SHARE ACCOUNT

Shares Acquired: Date	No. of Allotment or Transfer	Transferor's Folio	No. of Shares acquired	Distinctive Numbers: From	To	Shares Transferred: Date	Transfer No.	Transferee's Folio	No. of Shares transferred	Distinctive Numbers: From	To	Balance of Shares held
1906. June 7	18		100	751	850	1906. Aug. 2	6	87	50	751	800	50

CASH ACCOUNT

Amounts Payable (Dr.): Date	Particulars	Amount per Share	Fo.	Amount	Cash Paid (Cr.): Date	Particulars	Fo.	Amount
		£					C.B.	
June 1	To Application	1		100 0 0	June 1	By Cash Application	1	100 0 0
June 7	,, Allotment	2		200 0 0	,, 8	,, Cash Allotment	10	200 0 0
July 7	,, First Call	2		200 0 0	July 9	,, Cash First Call	25	200 0 0

Subject to the articles of association, members are allowed to transfer their shares, should they at any time wish to do so, and it may be pointed out that this is a further difference between limited companies and partnerships, for in the latter a member is only allowed to transfer his share in the business with the consent of his partners.

Forfeiture of Shares. A provision is usually inserted in the articles of association giving the directors power to forfeit any shares upon which calls are in arrear. Notice must be given to the shareholder of the intention to forfeit, and, if he fails to pay, a resolution may be passed declaring his shares forfeited, whereupon he will cease to have any further interest in them. The company will retain the amount paid up on the shares, and will be at liberty to issue them afresh to any other person willing to take them, who may be required at the discretion of the directors to pay either the full amount or the balance unpaid by the original shareholder.

Upon the shares being forfeited, entries would be made in the general ledger giving effect to the operation by reducing the amount to the credit of the capital account to the extent of the sum called up on the shares forfeited, and by writing off from the sundry shareholders' account the balance due and unpaid on the shares. The journal entries giving effect to the transaction would be as given at the head of the next page, and would be posted to the respective ledger accounts in the usual way.

Purchase of a Business. The entries necessary to record the taking over by a company of the assets and liabilities of a vendor follow the usual lines in opening the books of an ordinary business. Accounts are opened for the assets and debited with their book values, the vendor being credited with the total. The liabilities taken over by the company are then credited to their respective accounts and the vendor is debited with the total. The result is that the books show all the assets acquired and all the liabilities assumed by the company, while the balance of the vendor's account represents the net amount payable to him for his business. If he is paid the whole amount in cash he is debited as the payments are made to him; cash, of course, being credited.

The vendor sometimes agrees to take part of his purchase price in shares of the company, which are issued to him credited as being paid up—*i.e.*, the company's liability to him for his property is set off against his liability to the company on the shares to the extent of the nominal value of the latter. When payment is made in this way the vendor is debited with the nominal value of the shares and the share capital account is credited. The result will be the closing of his account, as the payments in cash or shares being for the difference due to him will exactly balance the account. An account is opened for him in the share ledger, in which he will be shown as the holder of the shares allotted to him, credited with the full amount paid up.

Dec. 31	Share Capital Account.. .. .. Dr.	250 0 0	
	To Forfeited Shares Account..		250 0 0
	For amount called up on 50 shares in name of John Jones, this day forfeited by resolution of Directors		
„ 31	Forfeited Shares Account .. .. Dr.	100 0 0	
	To Sundry Shareholders' Account		100 0 0
	For amount unpaid on above 50 shares		

To make these processes quite clear an example of the acquisition of a business will be taken. W. Brown, a tailor, after having carried on business successfully for some years, decides to retire and dispose of his business to a limited company. His assets consist of his freehold shop and premises valued at £4,500; stock-in-trade, £500; book debts, £3,000; cash at bank and in hand, £350. His liabilities are, on bills payable £280, and on open accounts £420, leaving as his capital £7,650. The company takes over all the assets except the cash, and undertakes to discharge the liabilities. The excess of the assets acquired over the liabilities assumed is, therefore, £7,300. The price required by Brown is £9,000, the difference being the amount charged by him for goodwill. He agrees to accept payment of this price, £6,000 in cash and £3,000 in shares. The journal entries necessary to record the transfer and payment are as follows:

Jan. 1	Freehold Premises .. .. Dr.	4,500 0 0	
	Stock .. .. „	500 0 0	
	Sundry Debtors.. .. .. „	3,000 0 0	
	Goodwill .. .. „	1,700 0 0	
	To W. Brown Purchase Account		9,700 0 0
	For the price of assets purchased as per agreement dated		
„	W. Brown Purchase Account .. .. Dr.	700 0 0	
	To Bills payable		280 0 0
	„ Sundry Creditors..		420 0 0
	For liabilities assumed by Company under Agreement dated		
„	W. Brown Purchase Account.. .. .. Dr.	3,000 0 0	
	To Share Capital Account		3,000 0 0
	For shares allotted to him in part payment for business as per agreement dated		

Brown will also be debited and cash credited with the £6,000 payable in cash as and when the amount is paid. The student should now open the ledger accounts and post thereto the various journal and cash book entries in order that the full effect of the transactions may be appreciated.

Companies' Balance - Sheets. The assets and liabilities of limited companies are not, as a rule, arranged in the same order in the balance sheet as those of an individual or a firm. Table A of the Companies' Act, 1862, besides providing a model set of regulations for a company, also gave a form of balance sheet to be used by companies governed by those regulations; and the order there laid down is very generally adopted by companies having articles of association of their own.

The order of the liabilities as given in the form is (1) the capital, showing the number of shares and the amount per share paid, with particulars of any arrears and forfeited shares; (2) the debts and liabilities, showing loans on mortgages or debenture bonds, debts on bills, open accounts and for interest, and also any amounts due to shareholders for unclaimed dividends; (3) any reserve funds; (4) the balance of the profit and loss account available for dividend; and (5) any contingent liabilities, being either claims not acknowledged as debts or amounts for which the company is only contingently liable.

The order of the assets is: (1) property held by the company, showing (*a*) immovable property, distinguishing freehold and leasehold land and buildings; and (*b*) movable property, distinguishing stock, plant, etc., and giving both cost and deductions for depreciation; (2) debts owing to the company, showing those considered good for which the company (*a*) holds bills or (*b*) has no security, and those considered doubtful or bad (any debt due by an officer of the company must be separately stated); (3) cash and investments, showing the natures of the investments and the whereabouts of the cash.

Companies' Profits. One point that emerges from the foregoing is that the balance of the profit and loss account is not transferred to the capital account, but is shown separately and distinctly in the balance-sheet. This is always necessary in the case of a company, whatever has been the result of the trading. If there has been a loss the balance will appear on the assets side of the balance-sheet. The disposal of the profit is usually shown in the ledger in an account called the Appropriation of Profit Account, a specimen of which, with the balance-sheet of a company, is given later.

J. F. G. PRICE

A Special Dictionary explaining Commercial Terms and Phrases appears at the end of the Self-Educator

Carpeting Floors and Papering Walls. Cubical Content and Problems connected therewith. Time, Distance, and Speed.

CUBICAL CONTENT

CARPETING FLOORS AND PAPERING WALLS

155. All problems on carpeting floors, papering walls, painting surfaces, etc., depend on the same thing—*viz.*, that length × breadth = area.

In the carpeting of floors, an arithmetical question always assumes that the floor is a rectangle, and no allowance is made for "matching" the pattern of the carpet. The carpet is taken from a long roll of given width, and all the student has to do is to find what *area* of carpet is required (by multiplying together the length and breadth of the room) and then to find what *length* must be cut from the roll to supply this area (by dividing the area by the width).

The cost of the carpet is generally given as so much per linear yard. Then, since the number of yards required is known, the total cost of covering the floor is easily found.

Example 1. Find the cost of covering a floor, 18 ft. long, 15 ft. broad, with carpet 27 in. wide, at 4s. a yard.

Area of carpet required $= 18 \times 15$ sq. ft.
Width of carpet $= 27$ in. $= 2\frac{1}{4}$ ft.

$$\therefore \text{Length reqd.} = \frac{18 \times 15}{2\frac{1}{4}} \text{ ft.} = \frac{18 \times 15}{2\frac{1}{4} \times 3} \text{ yd.}$$

$$\therefore \text{Cost} = £\frac{18 \times 15 \times 4}{2\frac{1}{4} \times 3 \times 20}$$

$$= £\frac{\overset{2}{\cancel{18}} \times \cancel{15} \times \cancel{4} \times 4}{\cancel{9} \times \cancel{3} \times \cancel{20}} = \underline{£8 \text{ Ans.}}$$

Notice that the *length* of carpet is *linear* feet, and therefore we divide by 3, not by 9, to reduce it to yards. The cost is found by multiplying the number of yards by the price of a single yard—*i.e.*, 4s. This would give the answer in shillings. We therefore put 20 in the denominator, to reduce the amount to £'s.

It should be particularly noted that there is no need to work out any portion of the sum until we get to the cost. We do not want to know the actual area of the floor, or the actual length of carpet required.

Example 2. A room 21 ft. square has the middle covered with a carpet 16 ft. square, at 9s. a square yard, and the space round the carpet is stained, at 10d. a square foot. Find the total cost.

Area of floor $= 21 \times 21$ sq. ft. $= 441$ sq. ft.
Area of carpet $= 16 \times 16$ sq. ft. $= 256$ sq. ft.
$\therefore$ Area to be stained $= 441 - 256 = 185$ sq. ft.
$\therefore$ Cost of staining $= 1850$d. $=$ £7 14s. 2d.
Price of carpet $=$ 1s. per sq. ft.
$\therefore$ Cost of carpet $=$ 256s.
$=$ £12 16s.
$\therefore$ Total cost $=$ £7 14s. 2d. $+$ £12 16s.
$=$ £20 10s. 2d. *Ans.*

The student must be careful not to confuse the two expressions, "21 feet square" and "21 square feet."

156. The simplest way of finding the area of the walls of a room is to find the distance round the floor, or the *perimeter*, and multiply by the height. This is equivalent to placing the four walls into one long wall, and multiplying the length by the height to obtain the area.

Thus, a room 18 ft. long, 15 ft. broad, 10 ft. high, if measured round the four sides of the floor, would give $(18 + 15 + 18 + 15)$ feet for the length of our "imaginary" wall. Therefore, the area of the four walls is $(18 + 15 + 18 + 15) \times 10$ sq. ft.; or

Twice (Length + Breadth) × Height = Area of Walls.

The problem of finding the cost of papering the room is now the same as that of carpeting a floor. We have only to divide the area of the walls, which is the area of paper required, by the width of the paper, and we obtain the length of paper required. Then, when we know the price per yard, the cost of the entire amount is easily found.

Example. Find the cost of papering a room 24 ft. long, 18 ft. wide, 12 ft. high, with paper 21 in. wide, at 2s. 9d. per piece of 12 yd.

Area of walls
$= 2(24 + 18) \times 12$ sq. ft. $= 2 \times 42 \times 12$ sq. ft.
Width of paper $= 21$ in. $= 1\frac{3}{4}$ ft.
Therefore, Length of paper required

$$= \frac{2 \times 42 \times 12}{1\frac{3}{4}} \text{ ft.} = \frac{2 \times 42 \times 12 \times 4}{7 \times 3 \times 12} \text{ pieces.}$$

Therefore, Cost

$$= £\frac{\overset{2}{\cancel{2}} \times \cancel{42} \times \cancel{12} \times \cancel{4} \times \overset{11}{\cancel{33}}}{\cancel{7} \times \cancel{3} \times \cancel{12} \times \underset{5}{\cancel{20}} \times \underset{3}{\cancel{12}}} = £\frac{11}{5} = \underline{£2 \text{ 4s. Ans.}}$$

CUBICAL CONTENT

157. We have now to consider the measurement of volume, or solidity. Just as the rectangle is the chief surface considered in arithmetic, so the *rectangular solid* is the chief solid body.

A rectangular solid is bounded by six rectangular surfaces, each opposite pair of rectangles being equal and parallel to each other.

A rectangular solid thus has *three* dimensions—*length, breadth,* and *thickness.*

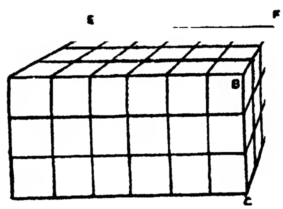
If the length, breadth, and thickness are all equal to one another, the solid is called a *cube.*

Hence, a cubic *yard*, the unit of volume, is a solid body whose length, breadth, and thickness are each a linear *yard*. Similarly, a cubic inch measures one linear inch in length, breadth, and thickness; and a cubic *foot* measures one linear *foot* in length, breadth, and thickness.

158. The number of cubic feet (or inches, or yards) in the volume of a rectangular solid is equal to the number of linear feet (or inches, or yards) in the length, multiplied by the number of linear feet (or inches, or yards) in the breadth, multiplied by the number of linear feet (or inches, or yards) in the thickness.

This is usually abbreviated into

Length × Breadth × Thickness = Volume, or Cubic Content.



For, suppose the solid in the diagram is 6 ft. in length, 4 ft. in breadth, and 3 ft. in thickness. It is clear that the solid can be cut into three slices, each 1 ft. thick, by planes parallel to the face ABFE. But, by Art. **153**, the face ABFE contains 6 × 4 sq. ft., and under each square foot there is a cubic foot. Thus, each slice contains 6 × 4 cubic ft. Therefore, since there are three slices, the whole solid contains 6 × 4 × 3 cubic ft.

159. Since,

Length × Breadth × Thickness = Cubic Content,

it follows that, if we know any three of these four quantities, we can find the fourth.

160. The student should remember that

(*a*) A cubic foot of water weighs 1000 oz. (avoir.), approximately.

(*b*) A gallon of pure water weighs 10 lb. (avoir.), or,

"A pint of clear water
Weighs a pound and a quarter."

We have thus a relation between weight, capacity, and cubic content.

Example 1. A tank 7 ft. long, 6 ft. broad, is filled to the depth of 2 ft. with water. How many gallons of water are in the tank ?

Amount of water = 7 × 6 × 2 cubic ft.

$$= \frac{7 \times 6 \times 2 \times 1000}{16} \text{ lb.}$$

$$= \frac{7 \times \overset{3}{\cancel{6}} \times \cancel{2} \times \overset{25}{\cancel{1000}}}{\underset{\cancel{4}}{\cancel{16}} \times \cancel{10}} \text{ gal.}$$

$$= \underline{525 \text{ gals. } \mathit{Ans.}}$$

Example 2. An open tank made of iron $\frac{1}{4}$ in. thick, is 4 ft. long, 2 ft. 6 in. broad, and 2 ft. deep, outside measurement. Assuming that iron weighs 7·8 times as much as water, find the weight of the tank.

The external volume of the tank

$$= 2 \times 2\tfrac{1}{2} \times 4 \text{ cubic ft.} = 20 \text{ cubic ft.}$$

Since the iron is $\frac{1}{4}$ in. thick, the inside length is $\frac{1}{2}$ in. less than the outside, the inside breadth is $\frac{1}{2}$ in. less than the outside, and the inside depth is $\frac{1}{4}$ in. less than the outside.

Therefore, the interior volume

$$= 29\tfrac{1}{2} \times 47\tfrac{1}{2} \times 23\tfrac{3}{4} \text{ cubic in.}$$

$$= \frac{59 \times 95 \times 95}{16} \text{ cubic in.}$$

$$= 33279\tfrac{11}{16} \text{ cubic in.}$$

Therefore, volume of iron in the tank

$$= 20 \text{ cubic ft.} - 33279\tfrac{11}{16} \text{ cubic in.}$$

$$= 1280\tfrac{5}{16} \text{ cubic in.}$$

But 1 cubic ft. of iron weighs as much as 7·8 cubic ft. of water, *i.e.*, 7·8 × 1000 oz., or 7800 oz.

$$\therefore \text{Weight of tank} = \frac{1280\frac{5}{16} \times 7800}{1728 \times 16} \text{ lb.}$$

$$= 361{\cdot}199 \text{ lb. } \mathit{Ans.}$$

Example 3. The areas of the faces of a rectangular solid are 35 sq. ft., 21 sq. ft., and 15 sq. ft. respectively. Find the length of each edge.

The areas of the faces of a rectangular solid are (i.) length × breadth ; (ii.) breadth × depth ; (iii.) length × depth. If we multiply these together we obtain $(\text{length})^2 \times (\text{breadth})^2 \times (\text{depth})^2$, and the volume of the solid is the square root of this product.

Hence, the volume of the given solid

$$= \sqrt{35 \times 21 \times 15} \text{ cubic ft.}$$

$$= \sqrt{3^2 \times 5^2 \times 7^2} \text{ cubic ft.}$$

$$= 3 \times 5 \times 7 \text{ cubic ft.}$$

Therefore,

$$\left.\begin{array}{l} \text{Length} = (3 \times 5 \times 7) \div 15 = 7 \text{ ft.} \\ \text{Breadth} = (3 \times 5 \times 7) \div 21 = 5 \text{ ft.} \\ \text{Depth} = (3 \times 5 \times 7) \div 35 = 3 \text{ ft.} \end{array}\right\} \underline{\mathit{Ans.}}$$

162. We have seen [Art. **153**] that surface is of *two* dimensions—*i.e.*, we find the area of a rectangular surface by multiplying *two* quantities together. If, then, we have two rectangles, of which one is twice the length and twice the breadth of the other, the *area* of the first will be 2^2, or 4, times the area of the other. Or, if the dimensions of the first are 3 times the dimensions of the second, the area of the first will be 3^2 times the area of the second.

Similarly, since cubical content is of *three* dimensions, if we have two rectangular solids in which the dimensions (length, breadth, thickness) of the first are any multiple, say 3 times the dimensions of the second, the *volume* of the first will be 3^3, or 27, times the volume of the second.

But it should be noticed that *area* of the six surfaces of the first solid will only be 3^2, or 9, times the area of the surfaces of the second.

Example 1. The cost of thatching varies as the area thatched. If it costs £4 to thatch a stack 16 ft. high, how high is a *similar* stack which it costs £2 5s. to thatch ?

£2 5s. is $\frac{9}{16}$ of £4. Therefore the area thatched in the second case is $\frac{9}{16}$ of that thatched in the first case. Hence, each dimension of the second stack is $\sqrt{\frac{9}{16}}$, or $\frac{3}{4}$, of the corresponding dimension in the first stack.

But, the first stack is 16 ft. high, therefore the second is $\frac{3}{4}$ of 16 ft., or <u>12 ft. high *Ans.*</u>

Example 2. What is the value of a silver coin *similar* to a sixpence, but twice as thick ?

The coins are similar, so that every dimension (*viz.*, length, breadth, and thickness) of the one is twice the corresponding dimension of the other. Therefore the content of one coin is 2^3 or 8 times the content of the other.

Hence, the value of the second coin is 8×6d. $= 4$s. *Ans.*

Example 3. The dimensions of a rectangular box are as 3 : 4 : 5. The difference between painting the outside at 6d. and at 7d. a square foot is 17s. 7½d. Find the dimensions of the box.

Suppose the box to be 3 ft. × 4 ft. × 5 ft. The total area of the six faces would be

$$2\{(3 \times 4) + (4 \times 5) + (3 \times 5)\} \text{ sq. ft.} = 94 \text{ sq. ft.}$$

But, the difference between the costs at 6d. and at 7d. a foot = 17s. 7½d. = 211½d.

Therefore, the actual area of the six faces is 211½ sq. ft.

Thus,

Actual area : supposed area :: 211½ : 94
:: 423 : 188

Therefore, each dimension of the actual box

$$= \sqrt{\tfrac{423}{188}} = \sqrt{\tfrac{9}{4}}$$

$= \frac{3}{2}$ of the corresponding dimension of the supposed box.

Hence,

$$\left.\begin{aligned} \text{Length} &= \tfrac{3}{2} \times 5 \text{ ft.} = 7\tfrac{1}{2} \text{ ft.} \\ \text{Breadth} &= \tfrac{3}{2} \times 4 \text{ ft.} = 6 \text{ ft.} \\ \text{Depth} &= \tfrac{3}{2} \times 3 \text{ ft.} = 4\tfrac{1}{2} \text{ ft.} \end{aligned}\right\} \textit{Ans.}$$

EXAMPLES 19

1. A rectangular field, three times as long as it is broad, contains 30 acres. Find its length and breadth.

2. Find the cost of the paper for a room 17 ft. 9 in. long, 13 ft. 9 in. broad, and 12 ft. high, the paper being 21 in. wide, and its price 2s. 8d. per piece of 12 yd.

3. The floor of a room 21 ft. square has a square carpet in the middle, costing 5s. 3d. per sq. yd. The outside border is covered with oil-cloth at 2s. per sq. yd. Had the whole floor been covered with carpet, the cost would have been increased by £3 18s. Find the width of the oil-cloth border.

4. A rectangular cistern is 6 ft. long, 4 ft. wide, and 3 ft. deep inside measurement. Find the cost of lining it with lead, weighing 8 lb. to the square foot, at 10s. 2d. per cwt.

5. It costs £2 17s. 9d. to paper a certain room. What would the cost have been if the room had been twice as long, twice as broad, and half as high again ?

6. The cost of levelling and turfing a square cricket field at 10d. per square yard is £852 0s. 10d. What will it cost to surround the field with an iron fence at 8s. per yard ?

7. The dimensions of a rectangular box are as 7 : 5 : 3, and its volume is 13,125 cubic in. Find its dimensions.

TIME AND DISTANCE

163. The speed, or rate at which a body is moving, is measured by the distance through which the body would move in a given time.

Thus, when we say that at some particular instant a person is walking at 4 miles an hour, we mean that if he continues walking at the same pace as at that particular instant he will go 4 miles in the hour.

A person walking at the rate of 4 miles an hour, will go 8 miles in 2 hours, 12 miles in 3 hours, and so on. Hence,

$$\text{Rate} \times \text{Time} = \text{Distance} ;$$

and when we know any two of these quantities we can find the third.

164. In many questions on speed, it is useful to be able to convert readily "miles per hour," into "feet per second." For this purpose we shall first find what rate in feet per second is equal to 60 miles per hour.

60 miles per hour

$$= 60 \times 1760 \times 3 \text{ ft. in } 60 \times 60 \text{ seconds}$$

$$= \frac{60 \times 1760 \times 3}{60 \times 60} \text{ ft. per second}$$

$$= 88 \text{ ft. per second.}$$

Remembering this result, we can easily convert any other rate from miles per hour to feet per second. For example, 20 miles per hour is $\frac{20}{60}$ of 88 ft. per second, *i.e.*, $\frac{88}{3}$ ft. per second.

165. Suppose two persons walking along the same road, the first at 4 miles an hour, and the second at 3 miles an hour. Then, if they are walking towards one another, at the end of 1 hour they will have diminished the distance between them by 4 + 3 miles, *i.e.*, they approach one another at the rate of 7 miles an hour. Or, if the first person is following the second, at the end of 1 hour they will have diminished the distance between them by 4 − 3 miles, *i.e.*, they approach one another at the rate of 1 mile an hour. Hence, if we know their distance apart at any particular time, we can find how long after that time it will be before they meet.

Example 1. The distance between Edinburgh and London is 400 miles. At 12 noon a train leaves Edinburgh for London at 40 miles an hour, and 1 hour later a train leaves London for Edinburgh at 50 miles an hour. When, and at what distance from London, will they meet ?

At 1 o'clock, the train from Edinburgh has travelled 40 miles, so that, when the other train leaves London, the two are 400 − 40, *i.e.*, 360 miles apart. But they approach one another at the rate of 40 + 50, or 90 miles per hour.

Therefore, the time till they meet = 360 ÷ 90 = 4 hours after 1 o'clock.

In 4 hours the train from London travels 4 × 50 miles = 200 miles.

Hence, the trains meet at 5 o'clock, 200 miles from London. *Ans.*

Example 2. The rates of two cyclists are as 11 : 8. They start together from the winning post and race round a circular track. The better man passes the other every 4 minutes, and when the race ends they are passing the

winning post together for the first time. How long did the race last?

Since 11 and 8 are prime to one another, it is clear that they will first pass the winning post together when the first has ridden 11 times round and the second 8 times round.

The faster man thus gains $11 - 8$, or 3, rounds during the race. But, he passes the other man every 4 minutes, *i.e.*, he gains 1 round in 4 minutes. Hence, he will gain 3 rounds in 3×4 minutes, *i.e.*, the race lasted 12 minutes *Ans.*

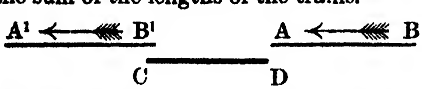
Example 3. Three men ride round a circular track 2112 yd. in circumference. The first goes 440 yd. a minute, the second 352 yd., and the third 344 yd. If they start together, riding in the same direction, how long will it be before they are together again?

The first man gains on the second at the rate of $440 - 352$, or 88 yd. per minute. Since the distance round the track is 2112 yd., the time till the first man again passes the second is $2112 \div 88$, *i.e.*, 24 minutes.

Similarly, the first man gains on the third at the rate of $440 - 344$, or 96 yd. per minute. He will, therefore, pass the third man again after $2112 \div 96$, *i.e.*, 22 minutes. Hence, the first man will pass both the others together after the L.C.M. of 24 and 22 minutes, *i.e.*, 264 minutes, or 4 hours 24 minutes *Ans.*

166. In the case of a train of given length passing a certain point, or of two trains passing one another, we have to consider the distances travelled. It is clear that, in the first case, the train has to travel a distance equal to its own length, so that, knowing the length of the train and its rate, we can find the time taken to pass a given point.

In the case of one train passing another, the one train must *gain* on the other a distance equal to the sum of the lengths of the trains.



Suppose AB and CD to be two trains, and let the train AB be moving in the direction shown by the arrow. Then, whether the train CD be moving in either direction or whether it be standing, it is evident that when the two trains are again clear of one another, their relative position will be that shown by A^1B^1 and CD. Thus, the one train has travelled, relative to the other, a distance AA^1, which is the distance equal to the sum of the lengths of the trains.

Example. Two trains of lengths 77 yd. and 88 yd. are moving at 45 miles and 30 miles per hour respectively. Find how long they take to pass each other (i.) when they are moving in opposite directions; (ii.) when they are moving in the same direction.

(i.) When they are moving in opposite directions their relative speed is

$$45 + 30 = 75 \text{ miles per hour.}$$

$$= \frac{75 \times 88}{60 \times 3} \text{ yd. per sec. [Art. 164].}$$

And, to pass one another, the one must move, relative to the other, through a distance $77 + 88 = 165$ yds.

Hence, they will pass one another in

$$\left(165 \div \frac{75 \times 88}{60 \times 3}\right) \text{sec.} = \frac{\cancel{165}^{\cancel{15}^{3}} \times \cancel{60}^{\cancel{12}} \times 3}{\cancel{75}_{\cancel{5}} \times \cancel{88}_{\cancel{8}_{2}}} \text{ sec.}$$

$$= \frac{9}{2} = 4\tfrac{1}{2} \text{ sec. } Ans.$$

(ii.) When they are moving in the same direction their relative speed is

$$45 - 30 = 15 \text{ miles per hour.}$$

$$= \tfrac{22}{3} \text{ yd. per sec. [Art. 164].}$$

Hence, they pass one another in $(165 \div \frac{22}{3})$ seconds.

$$= \frac{\cancel{165}^{15} \times 3}{\cancel{22}_{2}} = \frac{45}{2} = 22\tfrac{1}{2} \text{ sec. } Ans.$$

167. In problems concerning the rate of a boat rowed with or against a stream the principle is the same.

If a man can row a boat, say at $4\frac{1}{2}$ miles an hour in still water, and he rows *against* a stream whose rate is $1\frac{1}{2}$ miles an hour, the actual rate of the boat will be $4\frac{1}{2} - 1\frac{1}{2}$, or 3 miles an hour.

Similarly, if he rows *with* the stream, the actual rate will be $4\frac{1}{2} + 1\frac{1}{2}$, or 6 miles an hour.

Example. A man rows 7 miles against a stream whose rate is 1 mile per hour in $1\frac{3}{4}$ hours. How long will he take to row back again?

Against the stream he rows 7 miles in $1\frac{3}{4}$ hours

$$= \frac{7}{1\frac{3}{4}} = 4 \text{ miles per hour.}$$

But the stream hinders him 1 mile per hour; therefore, in still water he rows $4 + 1 = 5$ miles per hour.

Hence, rowing down stream his rate is $5 + 1 = 6$ miles per hour. Therefore, to row 7 miles he will take $7 \div 6 = 1\frac{1}{6}$ hours = 1 hour 10 min *Ans.*

Answers to Arithmetic

Examples 18

1. $3 \times 7 \times 13 = 273$.
2. $2^2 \times 17 = 68$.
3. $5^2 \times 11 \times 19 = 5225$.
4. 77.
5. $2^3 \times 3 \times 11 = 264$.
6. $5 \times 23 = 115$.
7. 314·27.
8. 1·7728 . . . = 1·773.
9. (i.) 314; (ii.) 210·063.
10. $\sqrt[3]{13\frac{203}{512}} = \sqrt[3]{\frac{6859}{512}} = \frac{19}{8} = 2\frac{3}{8}$.
11. [illegible] 1 ft.
12. £19 5s. 4d. = 4624d. ∴ No. of books $= \sqrt{4624} = 68$ *Ans.*
13. £6 2s. 6d. = 245 sixpences. Had he spent as many sixpences each day as there were days, he would have spent $245 \div 5 = 49$ sixpences. ∴ the number of days $= \sqrt{49} = 7$ days *Ans.*
14. Height of the top of the window above the ground $= \sqrt{50^2 - 14^2}$ ft. = 48 ft. Height of bottom of window above ground $= \sqrt{50^2 - 30^2}$ ft. = 40ft. Therefore, the window measures (48 − 40) ft. = 8 ft. from top to bottom.

H. J. ALLPORT

END OF VOLUME TWO

ACTIVE DENIZENS OF THE FORESTS

LION-MARMOSETS OF BRAZIL

FACING PAGE 1663

**The "Get-it-Over" View of Doing Work.
The Evils and Advantages of Specialisation.**

ON MASTERING ONE'S BUSINESS

"WHAT need can there be," it may be asked, "for insisting on mastering one's business as a condition of success? Cannot such a necessity be admitted as a matter of course?" The answer is that it is less and less a matter of course that a man will seek to master broadly the business of his life. Indeed, in every profession, business, calling, or craft a large preponderance of the workers do not seem to see that it is either a privilege, duty, or point of personal advantage to become thoroughly and scientifically acquainted with the whole range of the activities in which they are incidentally engaged.

The reason for this state of things is to be found in the extraordinary extension of what the old economists called "division of labour." In the manufacturing world machinery has divided work into minute parts that can be perfected with amazing swiftness and efficiency, and the attention and skill of the individual worker tend to become similarly concentrated within a narrow range. It seems likely that a time may arrive when nobody will be able to make anything completely, but each will be expert in one process of an elaborate combination of processes. Nobody will make a pair of shoes, but somebody will have abnormal skill in making the lace-holes. It is exactly the same with more advanced scientific or professional work; only, in that quarter, division of labour takes the more recent and acceptable name of specialisation. A man has no sooner made a fair start with any work that may give him a sound professional status than he is beset with demands that he shall declare his tastes and follow them into some separate and specialised department, where he can gain experience narrow in proportion to its efficiency. The result of these tendencies is that, to a large extent, acquaintance with business is departmentalised, and the wide and general knowledge which enables a man to become a supervisor, or a marshal of many forces, or a controller quick to see the coming changes that matter most, is much less common, though increasingly valuable.

The point that is emerging here is that between a mastery of one's business and specialisation, with its minute and excessive skill, there is a natural antagonism, at least on the surface. When a man can do a thing supremely well there is a temptation on the part both of himself and his employer to arrange that he shall go on doing it; but that is not the path to more than a very limited success. Whatever specialised skill may be attained, it is incumbent on every ambitious and intelligent worker to know a great deal about all the operations in the midst of which he is exercising his skill; and, so far from this being practised as a matter of course, it is one of the most neglected, though surest, avenues to success.

Some practical illustrations will, perhaps, best enforce this general statement of the position. Let us begin with banking. It may be questioned whether any form of modern work is carried on, in its more mechanical aspects, by so many discontented young men as banking. A young fellow leaves school with a fair general education, and his friends think they have served him very well when they have secured for him a nomination for a position in a bank, and given him a start there.

But a few years pass, and he begins to feel that he would rather be anything in the wide world than a bank clerk. What is he but a bookkeeper condemned to a round of dull entries and trivial calculations? The liveliest duty he can see immediately ahead of him is the passing of somebody else's money forward or backward across a counter. And this is all that a great many young men in banks can see. Therefore they become sated and wearied, and long for a change.

And yet at the back of the dull routine work of the bank, and waiting to be mastered by anyone who has energy, imagination, and insight, is the whole marvellous system of the world's finance, a field of operations crowded with opportunities for anyone who has sufficient grasp of mind and curiosity to master the

whole business. It is not the man's duty in life to continue indefinitely keeping accounts and handling money as a go-between, but to do these things on the way to understanding the whole science of money, and such branches of industry and business as are mixed up with the lending and borrowing of money—operations that have dignity and importance, and may tax the ability, shrewdness, and experience of the most alert. As for the discontented who are irked by the monotony of work from which they do not seriously attempt to rise, they may appropriately say, with Cassius, that the fault is not in their stars but in themselves if they are underlings.

A second illustration may be found in journalism. What proportion of men working as journalists can be said to have attempted to master their business? Many only set out with the idea of being reporters—a difficult, onerous, and honourable occupation, but one that ought not to set the bounds to the ambition of any man who is capable of being a sound reporter. Even when the reporter has limited his efforts to reporting he often learns little about the production of the journal to which he furnishes copy. That he should appreciate the points of view of sub-editors, and printers, and of publishers who have to catch trains, does not strike him as a natural and pressing duty. Sometimes, too, he is inclined to expect the particular forms of reporting in which he is expert to be reserved for him, and he resents simpler work as rather beneath his dignity; while the journalist whose ordinary task is to deal with opinion, or to use a more or less literary style, regards the writing of a report as a form of quite inferior activity.

Particularly the men who enter journalism from the outside are content to know little about the technique of the profession, if their writing is sufficiently original to command a market by its readableness or its more impressive qualities. In each of these instances a man detracts seriously from his value, and narrows greatly his opportunities for accepting the responsibilities attached to the most substantial success, if he does not set before himself the ideal of mastering thoroughly every phase of his business. Width of knowledge and adaptability will have a higher value with every upward step, for no one can be perfect in command who does not know how all kinds of things are done and the reason for doing them.

Another cogent illustration may be taken from school life. Forty years ago every teacher who was being trained for his work had before him, as his immediate ambition, the management of a school. He thought of that, and of nothing less. To teach a class was but an incident in the day's work. Organisation, so as to utilise limited resources to the utmost, was essential. The management of a considerable school was like the captaining of all the departments of a ship short-handed. Now the young teacher is trained, at the same age, to teach a class, which must not be too large, and must have a room to itself, and he becomes a "class-teacher." He calls himself distinctively by that name. If he were set to manage four classes at once in a large room he would be appalled. But that was what his predecessors often had to do for half an hour at a time, as a matter of course.

These comments are not made in defence of the old system of management in squadrons. But they do point to the fact that the old ideal embraced a mastery of the whole business, and the modern practice often stops short with departmental efficiency, limited in its scope, and failing to embrace much that every teacher should be interested in, and master of, including the broad aspects of education.

There is not a profession, industry, business, or trade from which similar examples might not be drawn. The question for each worker is whether he is content to be a cog in the machine, doing a limited amount of routine work for a limited remuneration, or whether he will seize every opportunity for gaining an understanding of the working of the whole machine. Some, it must be granted, are only fit to be cogs, repeating a fixed duty, but many who remain in that position do so not because they lack the ability to widen their skill and knowledge, but because they lack initiative, confidence, and will to prepare themselves for changes that may offer splendid opportunities.

The first secret of success in mastering any business thoroughly is that the worker shall feel an interest in the business, and shall turn on it an enterprising spirit of curiosity. But that is exactly what many seem to avoid. As it is their work, they are inclined to regard it as dull. They prefer to get away from it as much as

possible. They fancy that any other occupation would have greater freshness. Whereas the fact is that no craft or business activity is dull except to those who are themselves dull in spirit. Probably it is being pursued as a hobby by somebody with avidity, and is constantly becoming a source of pride to them as they attain more skill in it.

Take the mechanical forms of engineering as an example. One hears young apprentices complain that they are kept on at some quite simple mechanical work, and have little chance of acquiring adaptability. Whose fault is it? They can obtain a mastery of the tools of their trade if they really mean to have it; and an unlimited vista of skill opens out before any one of them. Let them read the lives of men like Henry Maudslay and William Murdock, who, besides splendid inventive genius, had a wonderful mastery over the simplest tools, as witness that fine tribute by a working man after Maudslay was known throughout the world as a master mechanic: "Oh, but he was a grand man with an eighteen-inch file!" There we get down to the bed-rock of Maudslay's enthusiasm and success. He loved the very elements of his work, and on them built up his fame.

To interest in one's work or profession must be added not only diligent practice, but study, and a determination to secure widening experience. Everybody who has any desire to avoid stagnation must have a hobby or study. Why should not a man's life-work be one of his hobbies that he will pursue through study during his spare hours? At least he should get together all the subsidiary knowledge about it that can be gained readily through books or by steady personal investigation. His trade may be but a fragment of an elaborate series of mechanical processes, as in the shoe trade, but surely it is better that he should make an effort to follow all the processes, understand the general working of the machinery, know something of the history of the materials used, and the reasons for their varying quality, and to be able to trace the finished product through the changing conditions under which it is marketed. Such knowledge will give a new dignity to his small share of the work; and who knows but that it may prepare him for taking wider responsibilities in the business if his natural capacity will admit of it?

THE BOYHOOD OF ABRAHAM LINCOLN, FROM THE PICTURE BY MR. HARRY WATSON, ENTITLED "WHAT OTHERS HAVE DONE, I CAN DO."

If collateral study is a fine supplement to technical labour, much more is it

essential to professional breadth. There is not one of the professions but is enveloped in romance if it be made the ground-plan for systematic reading and thought. Only thus can its underlying principles be adequately appreciated, and a broad outlook upon it be attained. We all know the difference between the reading doctor and the rote-work practitioner; between the rule-of-thumb scientist and the man who feels the flow of the great tides of thought of his generation; between the partisan and the publicist; and divergences as wide often come into the world's businesses and make the difference between success and failure. It is largely a question of outlook. One man has had what may be called business culture, and another has not. One has thought out the principles of his branch of industry, and has seen it in its true perspective, and the other has not. The man with the up-to-date, studious mastery succeeds; the routine worker in a groove fails.

The mastering of a business depends very largely on where the would-be learner goes for his experience—whether he knows how to take advantage of the incoming tide and avoid the ebb. Some years ago, in one of our Midland towns, trade was generally slack, and anyone making inquiries of the oldest and best established firms was answered invariably with a doleful shake of the head. Their machinery was idle, their reputation was of no assistance, and their short-time staffs spent much leisure in wondering what the world was coming to. And yet at that very time, in the same trade and the same town, young men with no capital began laying the foundations of rapidly growing fortunes. They had been wise enough to come freshly to a study of the business, without being hampered by any obsolete machinery, or being predisposed to run in grooves that had once been pathways of prosperity, but now were out-worn. Thus decreptitude and vigour came into startling proximity. Experience failed; insight flourished.

The same lessons may be read in many directions. Beware where you look for your experience, or you may find yourself afloat on the ebb tide. As a rule it is particularly wise to avoid those who are proud of being "practical men." Seldom have they any width of outlook. Their faith is usually pinned to the traditional methods of the fathers who served a generation which distrusted all that was new.

The mistake is not unknown on a national scale. There was a time when, in one of the leading agricultural counties, it used to be a local amusement to trace in the oracular utterances of a great parliamentary pundit, a Minister of the Crown, the opinions and practical advice given by an equally oracular local authority, whom everyone knew to be the stupidest of all men in his own line of business and up to his neck in failure. Yet his opinions, or rather dogged prejudices, were retailed to the House of Commons as the very quintessence of wisdom and practical guidance. To gather wisdom we must know where wisdom is, and that can only be known by breadth of survey and shrewd insight. The mastery of business needed is that which will fit tomorrow's needs. It is useless to go to the experience that toils heavily, in unobservant content, along the rutted roads of the past.

Because the need for a broad, as well as keen, interest in our life's business has been insisted on here, and the dangers of a too restricted specialisation have been pointed out, it must not be supposed that the value of specialisation is overlooked. Of course, there must be a concentration on a limited range of skill, or duty, or knowledge, till thoroughness is attained. Nothing is more fatal to success than a wandering mind. The best warranty that a man will be able to extend the range of his efficiency is found in the completeness with which he has mastered earlier, and perhaps simpler, duties or processes.

In many directions specialisation is the secret of success. Not only must each field of science, for example, be quartered diligently if original work is to be done, and professions like the law be divided into sections that will always remain large and complex; but every form of modern business demands specialists who concentrate themselves on particular phases—one as a buyer in special "lines," another as a salesman, a third as an organiser, and so forth, in growing sub-divisions—but while this is so, and will remain, the need exists everywhere for a wider outlook, so that the relation of special work to the whole may be borne in mind. It is the men with progressive knowledge, broad but thorough, who rise to supervision and control, and who, by the way, have the most interesting life as they pass from monotonous skill to varied knowledge.

JOHN DERRY

The Danube Basin. States of Austria-Hungary. Danubian Plain. Alpine and Carpathian Provinces. The Balkan Peninsula.

AUSTRIA AND THE BALKANS

All the regions hitherto described are crossed by rivers flowing to North European seas. The only remaining region, the Danube basin, is cut off from the rest of Germany by the Central Highlands and is drained to the Black Sea.

The sources of the Danube in the Black Forest are quite near the Rhine, but the two rivers immediately diverge. The Danube flows east along the base of the Swabian Jura, receiving, among other tributaries from the Alps, the Iller, with Ulm at its confluence, the Lech, on which is the old trading town of Augsburg, the Isar, on which is Munich (München), the capital of Bavaria, and the Inn from the Tyrol. The Inn enters the Danube among magnificent scenery, and at its confluence is Passau, the frontier town of Austria. Into that country we shall next follow it.

What Austria-Hungary Is. Austria-Hungary is a dual monarchy, consisting of the empire of Austria and the kingdom of Hungary, governed by an Emperor-King.

The Austrian Empire (116,000 sq. miles) consists of (1) Bohemia, Moravia, and Austrian Silesia, all in the Central Highlands; (2) the Danube archduchies of Upper and Lower Austria; (3) the Alpine duchies of Tyrol, Salzburg, Styria, Carinthia, and Carniola; (4) the Dinaric lands of Istria and Dalmatia, on the Adriatic; (5) the Carpathian lands of Galicia and Bukovina, on the northern foreland of the Carpathians. In the midst of these is Hungary (126,000 sq. miles), the plain of the Danube, surrounded in the north and east by the Carpathians and the Transylvanian Alps, the latter forming Transylvania, and in the west by the bare limestone mountains of Croatia-Slavonia. Bosnia and Herzegovina, north of the Balkan peninsula, which have been administered by Austria-Hungary since 1878, were formally annexed to the empire in 1908. Many different regions are thus united, occasionally, as in the case of Hungary and Bohemia, corresponding with geographical conditions, but often determined by merely political considerations. Austria-Hungary is, therefore, geographically unstable. It is also racially unstable. The different elements in the population—German and Slavonic in Austria; Magyar, Romanian, and Slavonic in Hungary—contend for mastery; constant friction attends their political union.

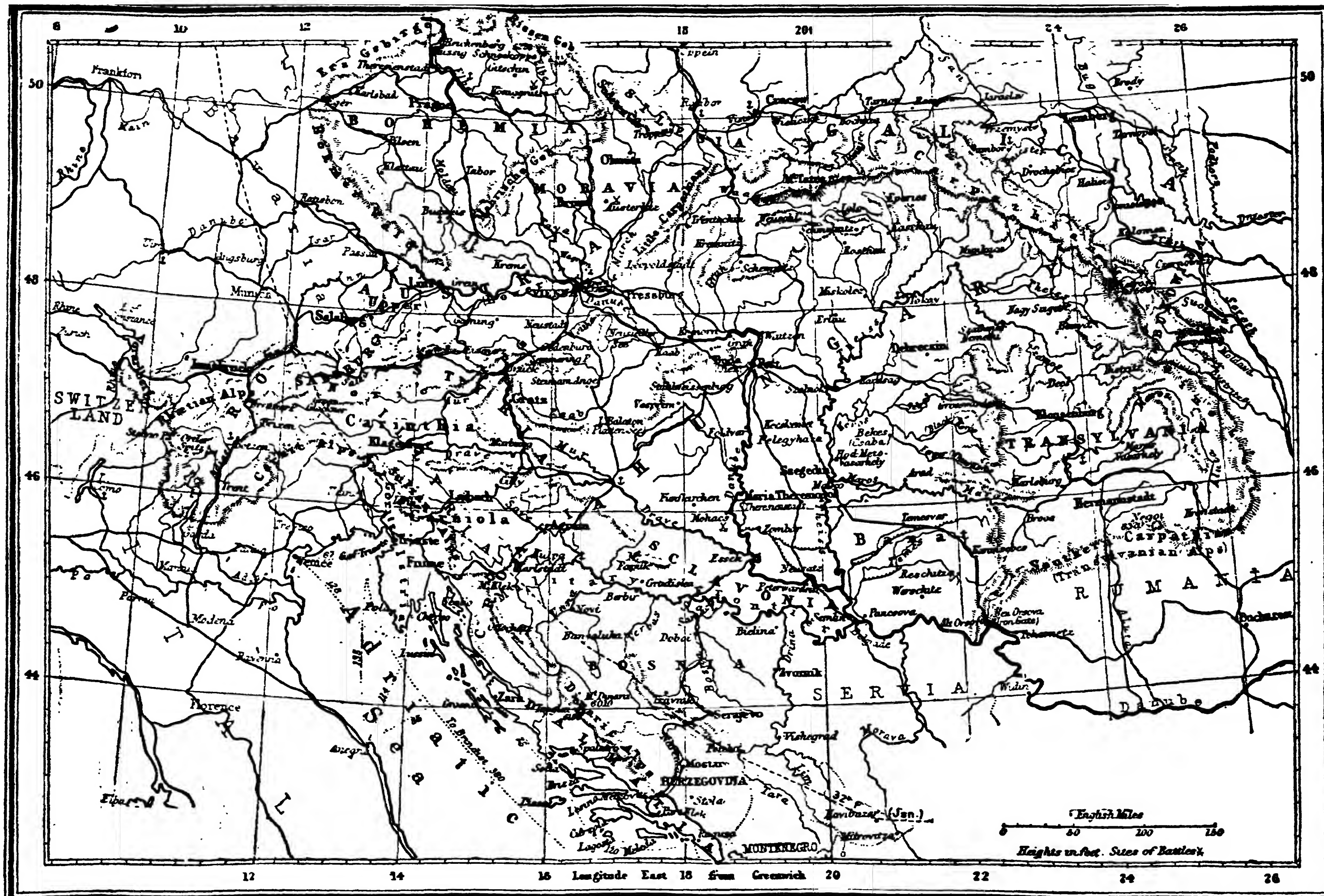
The Danube in Austria. A region so vast and diverse has too many varieties of climate, products and occupations to be described as a whole. What unity it has comes from the great Danube, which enters Austria at Passau, where it receives the Inn, its only tributary from the Swiss Alps. Below Passau it flows between the Alps and the Bohemian Mountains, forming the Austrian Gate, at the eastern end of which Vienna is built.

At Vienna the Danube is a magnificent river, rolling across a plain shut in to the south by spurs of the Styrian Alps projecting toward the little Carpathians, offshoots from the main range. Between these the river flows in a gorge known as the Hungarian Gate, where the Hungarian town of Pressburg is built.

A Magnificent View. All this is easily made out on the map, but it is thus a traveller translates the map's abstractions into realities: "To the east downwards the plain sinks into the horizon, and the towers of Pressburg, and even the foremost heights of the distant Carpathians, are discernible. To the south-west are offsets from the ridges of the Styrian Alps which form the rapids of the Danube. To the west the country rises from vineyards and orchards to precipices, forests, and mountains, the beginning of the Alps. To the south the lofty snow-clad summits of the Styrian Alps, embracing one side of the plain on which Vienna stands, and sending out promontories abruptly to the Danube, close the circle. In the midst of this vast panorama lies in full view the city of Vienna, with its cathedral and lofty spire rising against the sky; and far the most striking part of every view of which it forms part, the Danube, the monarch of European rivers, rolling its rapid and mighty stream." Just above Pressburg comes in the March from the Moravian Gate, flowing between the Bohemian Mountains and the Carpathians.

The Hungarian Danube. We are now in Hungary, with the Alps and Central Europe receding behind us. Pressburg is the gate of Eastern Europe, the direct road to that sea whose waters wash the shores of Asia. In the fertile plain which the Danube next crosses, the Raab comes in on the west from the Alps, and on the east tributaries descend from the Carpathians, which are broadest in the Hungarian Ore Mountains. Between these and the Bakony Forest on the west, at whose southern base is Balaton, the largest lake in Austria-Hungary, the river flows, and is turned south by the eastern spurs of the Bakony Forest. On these, the last heights in the Hungarian plain, is Budapest, the capital, a double city, Buda on the high west and Pest on the low east bank, together forming a city magnificent in natural beauty and architectural splendour.

The Plain of Hungary. Before us stretches the lake-like river, studded with wooded islands, and a vast plain loses itself on the distant horizon. Hundreds of rivers water it,



MAP OF THE EMPIRE OF AUSTRIA-HUNGARY

spreading their rich sediment over it in every flood. On its illimitable pastures are bred famous horses, and tens of thousands of cattle, sheep, and swine. It is, in fact, part of the great Eurasian steppe, and its Magyar inhabitants are true to the blood and the pastoral occupations of their Asiatic ancestors who centuries ago conquered a country so well suited to them. Elsewhere, ploughed fields, golden in summer, stretch far as eye can reach. The villages, with their orchards of plum and pear, and their shady acacias, are dotted about the plain, far apart, but large and prosperous. Through this land of green and gold the Danube flows south to meet the Drave, which has come down from the Tyrol, and along the eastern margin of the Croatian Mountains, behind which are the blue Adriatic and the Hungarian wheat and flour port of Fiume.

The united river keeps the direction of the Drave, receiving the Tisza, or Theiss, flowing from the Carpathians through corn lands and the famous vineyards of Tokay. Its last great tributary is the Save, which has come 700 miles from the Alps of Carniola and along the northwest margin of the Balkans; it receives the Drin from the south, the boundary between Bosnia and Servia, the latter of which fronts Hungary across the Danube. The Servian capital, Belgrad, is built at the confluence of the Save, and 50 or 60 miles lower the Danube forces its way between the Transylvanian Alps and the Balkans, in a series of grand defiles called the Klisura, terminating in the rapids of the Iron Gate, now made navigable by blasting and canalising. Here, at Orsova, it leaves Hungary.

Mountains and Climate of Hungary. So vast and rich are the plains that we often forget the mountains of Hungary. For 600 miles on the north and east the country is enclosed by the Carpathians, 150 miles broad at their broadest. The finest scenery is in the Tatra, where granite peaks, 8000 feet high, rise above lovely lakes. Oak, beech, and pine forests clothe the mountain side, with bear and wolf lurking in their unknown depths. Below are jewelled meadows and terraced vineyards. Minerals, such as gold, salt, and petroleum, are abundant. The occupations are mining, forest industries, cattle-rearing, and agriculture.

In Hungary we begin to experience the continental climate of Eastern Europe. The summers are hot, the winters very severe, except along the Adriatic coast. The products have already been described. Wheat, and timber from the forests of the highlands, are the chief exports.

Transylvania, Croatia, and Dalmatia. The mountain-girt Transylvania is watered by tributaries of the Maros, which breaks west through the mountains to the Danube. The capital is Kolosvar, or Klausenburg, a university and manufacturing town.

Croatia consists of bare limestone mountains, rising above the Adriatic, and of the fertile but marshy land between the Drave and Save. The bare, treeless mountains are "furrowed, pierced, and riddled into caverns, clefts, and gullies, valleys that have no outlets, and rivers without perceptible sources." This region is called the Karst. Agriculture and cattle-rearing are both backward. The capital is Agram.

To the north-east of Croatia is the Istrian peninsula at the base of the Alps, with the Austrian port of Trieste, behind which rise the bare mountains of the Karst.

To the south the Karst scenery continues in the wild Dinaric Alps, which descend 5000 ft. or 6000 ft. to the white towns, Ragusa, Cattaro, and others, of the Dalmatian coast. The summers are hot and dry, the winters mild and wet. Some evergreen forests remain, and on the lower Adriatic slopes the vine, olive, and orange are grown.

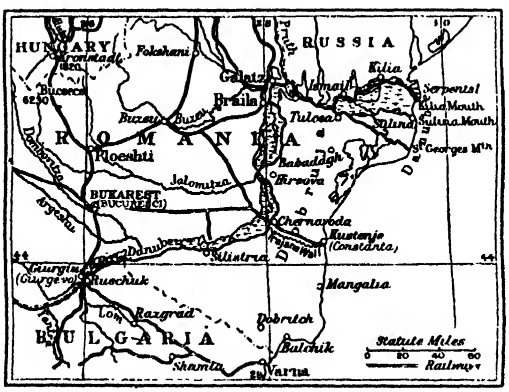
The Alpine Provinces of Austria. The scenery is of the Alpine type already described. The climate varies with elevation and situation. Valleys opening north and east have warm summers, but cold winters; the Adige and other valleys opening south have a climate which suits the vine and mulberry. In the higher Alps cattle-rearing is the chief occupation. Agriculture becomes important in the lower valleys and towards the Danube. Salt is abundant in the Salzkammergut, the picturesque district round Salzburg. Iron and lead are widely distributed in Styria, Carinthia, and Carniola. Besides Salzburg, the chief towns are Innsbruck, on the Inn, the capital of Tyrol, giving access to the fine rock scenery of the Dolomites; Graz, the capital of Styria, on the Mur, a tributary of the Drave; Klagenfurt, the capital of Carinthia, on the Drave; and Laibach, the capital of Carniola, on the Save. All these rivers and towns are connected with important routes across the Eastern Alps.

Upper and Lower Austria. These lie between the Alps and the Central Highlands, forming a transition between Germany and Hungary. They are mountainous, and thinly peopled. The chief towns are Linz and Vienna, at opposite ends of the Austrian Gate.

Bohemia. Bohemia consists mainly of the basin of the upper Elbe. It possesses many natural advantages which a prosperous people are quick to utilise. The climate of the surrounding mountains is severe in winter, but in the lowlands the vine can be grown as well as cereals; also sugar-beet, for making sugar; potatoes, for food and distilling; and hops, used in brewing famous beers, especially round Pilsen. The mountains yield valuable forests and cheap water-power, enabling papermaking and other forest industries to be carried on. Coal and iron are widely distributed, and kaolin, clay, and quartz in the northern mountains make Bohemian glass and porcelain famous. Wool from the highlands, and cotton and flax brought by the Elbe, are largely manufactured. Engines and railway plant are made at Prag, the capital, a city of palaces and factory chimneys, situated on heights above the Moldau. The majority of the inhabitants are Chekhs, but Germans are numerous in the towns.

Moravia and Austrian Silesia. Moravia lies east of Bohemia, between the Moravian Highlands and the Carpathians. The mountains have a severe climate, but the vine can still be grown in the lowlands, as well as barley and sugar-beet. Linen and woollen manufactures are important round Brünn, the capital. Silesia carries on manufactures on the Austrian portion of the Silesian coalfield. The capital is Troppau.

The Carpathian Provinces. Galicia and Bukovina are mountainous in the south, where the Carpathians rise to 5000 ft., but fertile in the north, where they sink to the plain. The climate is severe, the country being exposed to the snowstorms which sweep over Russia. Forests cover hundreds of square miles. In the lowlands cereals and potatoes are grown, and much spirit is distilled. Petroleum and rock salt are abundant, and a miniature underground town exists in the rock-salt mines of Wieliczka, near Cracow. This, the old Polish capital, in the narrow valley of the Vistula, commanding the route to the Moravian Gate, is a handsome city, manufacturing cloth and leather.



THE DELTA OF THE DANUBE

Bosnia and Herzegovina (20,000 sq. miles). Bosnia is a land of mountains and valleys, the former clad in magnificent but unproductive forests. Much of the surface has a mere film of soil, and is only fit for pasture. In the valleys, cereals, the vine, and immense quantities of plums are grown. Manufactures are in their infancy. The capital is Sarayevo. Herzegovina has the barren Karst scenery, but fertile valleys. The capital is Mostar, in the fine gorge of the Naronta.

THE BALKAN PENINSULA

The Balkan States. East of Bosnia and south of the Danube are the kingdoms of Servia and Bulgaria; the kingdoms of Montenegro, Albania, and Greece south of Herzegovina. A small strip of land between the Black and Ægean Seas is Turkish.

Romania. At Orsova the Danube enters the fertile plains of Romania (or Rumania), lying between the Transylvanian Alps and the Danube. These are crossed by innumerable rivers, flowing south to the Danube, the Romanian bank of which is low and marshy. The largest are the Sereth and the Pruth. The summers are hot, but the winters very severe, the temperature falling many degrees below the freezing point. Romania (50,000 sq. miles) is an agricultural land, growing immense quantities of wheat, shipped from Galatz and Braila, near the confluence of the Sereth; also hemp, flax, and tobacco. Petroleum is abundant and refineries numerous. Flour-mills, saw-mills, distilleries, cloth-mills, and tanneries abound.

The capital is Bukarest (Bucuresci). The Danube reaches the sea by a great delta, the branch most used for navigation being the Sulina. The total length of the river is 1800 miles.

A Transition Region. In the north of the Balkan peninsula we have the Central European climate and vegetation. The summers are warm and the winters severe. Oak and beech are the forest trees, the plum is the commonest orchard tree, and wheat the typical cereal. South of the Balkans, which curve round from the Transylvanian Alps, separating North Bulgaria from Eastern Rumelia, we pass into a different region. The summers are hot, and also dry. The winters are mild, and most of the rain falls at that season.

The rainfall is often so scanty that irrigation is necessary for agriculture. To suit this climate plants develop various peculiarities. The aloe has thick, fleshy leaves, which store up moisture; the cypresses, evergreen oaks, and the bushy stone-pines have small, hard leaves, which lose little moisture by evaporation. This type of climate and vegetation is characteristic of the Mediterranean region, to which we are now passing. The fruits are the vine, olive, orange, fig, pomegranate, peach, and apricot. The mulberry is largely cultivated to feed silkworms. Wheat is grown under irrigation, but millet and maize are better suited to the hotter, drier parts. Pulses, principally varieties of beans and lentils, are as important as root crops in Central Europe. One of them, lucerne, replaces grass as fodder. Cattle and horses, which need rich, moist pastures, give place to the hardier sheep, goats, mules, and asses.

Mountains and Rivers of the Balkan Peninsula. Almost the whole peninsula is mountainous, though the mountains do not rise above the snow line. They form part of the great Eurasian mountain system already described, and are known under various names in different parts, as the Balkans between Bulgaria and Eastern Rumelia, the Rhodope Mountains or Despoto Dagh in Bulgarian Macedonia, and the Pindus Mountains in Greece. In the north they are densely forested, but the forests have been destroyed in the south. Small plains, surrounded by mountains and difficult of access, are characteristic of the whole peninsula. Roads are bad, and communication backward.

Four important river valleys must be noticed: (1) The Morava, flowing north, across Servia, to the Danube; (2) the Isker, rising south of the Balkans, and breaking through them to

THE NEW GROUPING OF THE BALKAN STATES

THE BALKAN STATES AS REORGANISED AT A CONFERENCE OF THE POWERS AFTER THE WAR OF 1913

the Danube; (3) the Maritza, flowing round the northern and eastern base of the mountains of Thrace to the Ægean; and (4) the Vardar, flowing south to the Gulf of Saloniki. Notice that (1) the Morava and the Vardar, and (2) the Morava, Isker, and Maritza give through routes from north to south, and that the railways follow them.

Montenegro. Montenegro (6000 sq. miles) is a wild land of bare limestone mountains, with a small, hardy shepherd population numbering about half a million. The mountain scenery is of the Karst type, and agriculture is possible only in the wider valleys. The peasants' houses are often festooned with tobacco, which is of excellent quality. There are few roads, no industries, and little trade. The capital is Cetinje (Cetigne), a red-roofed village town in a mountaingirt plain, with a population under 5000.

Servia. Servia (35,000 sq. miles, including the territory wrested from Turkey during the war of 1912–13) includes the basins of the Morava and upper Vardar rivers. It consists of a lowland along the Danube, rising on the west and south-west to the wild mountains bordering Bosnia, Montenegro, and the new State of Albania on the east (where the Danube breaks through spurs of the Carpathians at the Iron Gate), and on the south-east, where the mountains are part of the Balkan and Rhodope system.

The valleys are generally fertile. Vast beech and oak forests feed countless herds of swine. In the clearings, sheep and cattle are kept. The agriculture is often primitive, the fertile soil producing excellent wheat, tobacco, vine, and fruits. Dried and preserved plums are an important export. Much plum brandy is also distilled. The capital, Belgrade, is finely situated on a hill, at the foot of which the Save joins the Danube. Uskub and Monastir are important towns in the conquered territory.

Bulgaria. Bulgaria (42,000 sq. miles) rises from the southern bank of the Danube to the crest of the densely forested Balkans, beyond which lie Eastern Rumelia (or Southern Bulgaria) and parts of Macedonia and Thrace, formerly belonging to Turkey, but annexed by Bulgaria at the close of the recent Balkan Wars.

In the Danube area maize and wheat are grown, but south of the Balkans we find the products of a hotter region, rice and cotton, as well as the vine and the ever-present plum. Mulberries and the silkworm are very important. In the Maritsa valley, the most fertile part contains many square miles of rose gardens, from which is distilled the famous Oriental perfume, attar of roses. Bulgaria is on the way to prosperity, and roads and railways are fairly well developed. Sofia, the capital, is a modern city in a mountain-girt plain, commanding the Isker route. Philippopolis, built on isolated heights in a wide plain, is the second city. The ports are Ruschuk, on the Danube; Varna, on the Black Sea; and Dedeugatch, on the Ægean.

Turkey in Europe. As a result of the war with the Balkan League (Bulgaria, Servia, Greece, and Montenegro) the area of Turkey in Europe has dwindled down from 62,000 sq. miles to 12,000. All that is left of the former extensive Turkish possessions in Europe is the part of Thrace lying between Constantinople and the Maritza River, with a small area to the west of that river.

Both agriculture and cattle-rearing are backward, and the peasantry are poor, ignorant, and oppressed. The capital is Constantinople, built in one of the finest situations in the world, where "the Sea of Marmora, the Bosphorus, and the wide and winding harbour of the Golden Horn meet, forming, as it were, a great lake round which the city extends, rising stage by stage along the slopes of the hills, minaret and dome lifting themselves one above another against the azure sky." Commanding the entrance to the Black Sea, where Europe and Asia all but touch, this is one of the finest strategic points in the world. Another key to the Black Sea and the lands beyond is Gallipoli, on the Dardanelles.

Adrianople, which was captured by the Bulgarians in 1913, and reoccupied by the Turks when war broke out between Bulgaria and her former allies, lies on the Maritza River, and is on the main route from Central Europe to Constantinople.

Greece. Greece, as a result of the Balkan war of 1913, has increased in area from 25,000 sq. miles to about 43,000, with a population of five millions. It consists of the southern and deeply indented portion of the peninsula, with many adjacent islands, is a land of mountains and small, isolated mountain-girt plains. The annexed territory includes Epirus, the greater part of Macedonia, and several large islands in the Ægean Sea.

The climate is typically Mediterranean, and irrigation is necessary in the drier parts. All Mediterranean plants are grown, but the chief export is the currant, a small dried grape. The sponge fisheries of the Ægean Sea are important. The capital is Athens, built much like Edinburgh, round a height between the mountains and the sea, with Piræus as its Leith. From Corinth a ship canal has been cut across the narrow isthmus of the same name between the mainland and the mulberry-leaf-shaped peninsula of the Morea. Patras exports currants. Salonika is a large and important port in the new territory.

Off the west coast are the Ionian Islands, all mountainous, with fertile valleys. Corfu is the most important. The islands of the Ægean are less fertile, and produce little but wine. Syra (Hermopolis), on a small island of the same name, is the centre of the Ægean trade. Crete was proclaimed part of the kingdom of Greece in 1912.

Albania. Albania (12,000 sq. miles, population about two millions) is a new, independent State, created by the Conference of London at the close of the Balkan War of 1912–13. It lies on the west of the peninsula, and its boundaries march with those of Montenegro, Servia, and Greece. The country is mountainous and rugged in the interior, and swampy and unhealthy towards the coast. Olives, hides, and wool are exported. The chief towns are Scutari, Durazzo, and Avlona.

The Old Masters' Landscapes. Wilson and Constable. The Barbizon School. Turner the Sun Worshipper. Impressionism. Japanese Influences.

THE LANDSCAPE PAINTERS

Of all the arts, that of landscape painting is the most modern. It belongs, more than any other, to our own time, though its beginnings can be traced back to the days when Giotto delivered the art of painting from Byzantine formalism, which had no eyes for the beauties of Nature. Indeed, the replacing of the flat gold backgrounds of Byzantine art by the naïve landscape setting of Giotto and his followers is the first link in that long chain of evolution which leads to the discovery of atmosphere and sunlight by Constable, Turner, and the Impressionists. The Giottesques, and all the Italians, even Perugino and Raphael, and in the North the Van Eycks, Memlinc, and all the other Primitives, never painted landscape for its own sake. In their pictures it is always entirely subordinate to the figures, and used either to fill an empty space in a pleasing manner or to enhance and accentuate the sentiment expressed by the figures for which it forms a background.

The First Painter of Landscape. Landscape, painted for sheer love of Nature, and for its own sake, did not appear before the seventeenth century, though a near approach to it was made by the Venetians Giorgione and Titian, and in the North, at an even earlier period, by J. Patinir (A.D. 1490–1550). The beautiful scenes from the Cadore country, which form the background of many of Titian's pictures, speak at least of his love for the picturesque district in which he was born and had passed his childhood, and there is at the Pitti Palace at least one drawing from his pen in which the fine scene in the Cadore is rendered for its own sake, without the addition of figures. Patinir took an obvious delight in the careful objective rendering of landscape, to which the figures that enact the scenes of sacred history are mere accessories; but his view, like that of "Velvet" Breughel (A.D. 1569–1625), who devoted himself to fantastic scenes of Paradise, with minutely executed flowers and animals, was purely objective—that is to say, impersonal and unemotional, and his colour limited to a conventional scheme.

The Classical Landscape. Nicolas Poussin, Rubens, and Claude Lorrain were the first real landscape painters, though one of them, Rubens, touched upon landscape only passingly, to show, as it were, that his genius could cope with every problem that came within the painter's field. The few landscapes he has left us have the same verve and vigorous, swinging brushwork as his figure subjects and great compositions, and range from the heroic and dramatic to the simple and rural. Nicolas Poussin had grown up in the classic atmosphere, and was steeped in the study of the antique and the Italian masters. At the same time he was a close observer of tree and cloud forms, the mastery of which enabled him to rearrange and combine them into formal compositions of arcadian scenes, in which figures and setting were at least co-ordinate in importance. He never rose above a convention which was the very negation of naturalism, and used Nature only as a source whence he drew the motifs for his pictorial inventions. His colour was as cold and formal as his design. He was the father of the classical or heroic landscape.

The Discoverer of Sunlight. With Claude Lorrain (A.D. 1600–1682) figures ceased to be of any importance, and sunlight with its varying effects first became the real subject of the picture, though even Lorrain did not consider Nature unadorned to be worthy of pictorial representation, and continued, like his precursors Nicolas and Gaspard Poussin, to weave its details into well-ordered combinations, from which classic ruins, temples, and columns were never allowed to be absent.

But with him trees and clouds and winding rivers ceased to be mere forms conventionally coloured. He noted the play of light and shade on these objects, and expressed in masterly fashion the different times of the day—the glow of sunset and the restful coolness of early morning. About two centuries later, his noble compositions were to become the starting-point for the greatest master of modern landscape—for Turner. Equally subjective in his view of Nature was Lorrain's Italian contemporary, Salvator Rosa, who depicted the romantic and turbulent aspect of landscape in the rugged ravines and wind-tossed trees that form the background for his scenes of strife.

Dutch Temperament. It was left to the seventeenth century Dutchmen, Ruysdael, Hobbema, and Cuyp, to establish the claims of landscape as a genre independent of figure painting. Whilst Ruysdael, in following the successful Allaert von Everdingen, sought for the picturesque in Nature, and found it in the wild rocks and seething mountain streams and waterfalls of a country he probably knew only through the work of his popular contemporary, Hobbema was the sympathetic painter of his own country, which he rendered with intimate simplicity, setting down things as he found them, in all their quiet homeliness. But neither Ruysdael, nor Hobbema, nor even the great Rembrandt, who brought the whole passionate intensity of his temperament into his landscapes, could realise entirely the colour of Nature and free their palette of the browns demanded by a time-honoured convention for the painting of

THE POND, BY COROT

came very near the modern spirit. The curious point about his art is that he gave a convincing air of reality to scenes which only had existence in his own imagination.

Richard Wilson. Landscape painting in England, in the early part of the eighteenth century, followed two directions, one of which aimed at dry, topographic correctness, and is best represented by Samuel Scott, a talented imitator of Canaletto, the other at Italianised classicism. Of this direction, Richard Wilson (A.D. 1713-1782) is the chief disciple. At his best Wilson is a worthy rival of Claude Lorrain, whose intentions and ideals he had made his own. Thomas Gainsborough is a kind of halfway house between the old style and the new vision which was to be introduced by Constable. His colouring, based on a pleasing scheme of brown, grey, and gold, is still arbitrary and conventional, but his scenes are no longer composed according to established rules. His are in more intimate communion with Nature; he is attracted by the peaceful charm of the English countryside, which needs no classic ruins for its appeal. At the same time his landscapes have still a trace of the artificiality of the period, and lack that fragrance of the soil which breathes from Constable's canvases.

foliage. Like all Dutch landscape painters, Ruysdael and Hobbema excelled in the rendering of cloudy skies, and the latter in the subtle characterisation of varied foliage. Cuyp (A.D. 1606-1672) and Paul Potter (A.D. 1625-1654) remain unequalled to this day as painters of cattle, and must be mentioned here, because both of them, and particularly the former, conceived the animals as part and parcel of the landscape in which they live and which they help to complete.

The Dutch Seascape Painters. Finally, there are the seascape painters, Van de Capelle, Simon de Vlieger, and Van de Velde, all of whom appear more interested in the nautical life of the invariably quiet waters than in the moods of the elements by which the modern painter of the sea is generally fascinated. The real subject of the early Dutch marine painters is thus not the sea, but the varied forms of shipping—fishing fleets, sea-fights, the embarking or landing of an army, sailing craft of every description—in short, the life of the sea. The Frenchman Joseph Vernet (A.D. 1714-1789), though, on the whole, still adhering to the idealistic and classicist tradition, was attracted by the stormy, turbulent aspect of the sea, but there is no terror and passion in his storms. The discovery of the moods of Nature was left to the more nervous modern temperaments.

Watteau. Before we turn to England we must mention Watteau, who, in his perfect balance of figures and landscape, in his rendering of soft atmospheric effects,

The Norwich School. An important school flourished towards the end of the eighteenth century at Norwich under the leadership of John Crome, better known as "Old Crome" (A.D. 1769-1821), who has, not without good reason, been called the English Ruysdael. He and his

EMBARKATION OF THE QUEEN OF SHEBA, BY CLAUDE LORRAIN
in the National Gallery, London

followers, among whom Ladbroke, Stark, and Vincent are the most important, show strong kinship with the Dutch landscape school. The same influence can be noticed in the seascapes of John Cotman, another prominent member of the Norwich school. All these painters went to Nature for their subjects, but to the old masters for their colouring. It was the mission of John Constable (A.D. 1776–1837) to discover the juicy green of meadow and wood, the movement of the foliage in the gentle breeze, and the groaning of the heavy bough in the storm. With him the tree ceased to be mere form—he covered the stem with trembling and sparkling foliage; and the sky was no longer a mere grey background, but a dome of atmosphere spanned over fields and gardens and woods. Constable's instinct for balancing the masses of light and shade, and the "full" and "empty" spaces, was such that he could set aside all the hard and fast rules of academic composition. His ardent love of Nature and of the English countryside is expressed in all his work. French artists and critics immediately recognised that he had opened a new page in the book of art, and hailed in him a master worthy of emulation.

THE HAYWAIN, BY JOHN CONSTABLE
on the painting now hanging in the National Gallery, London

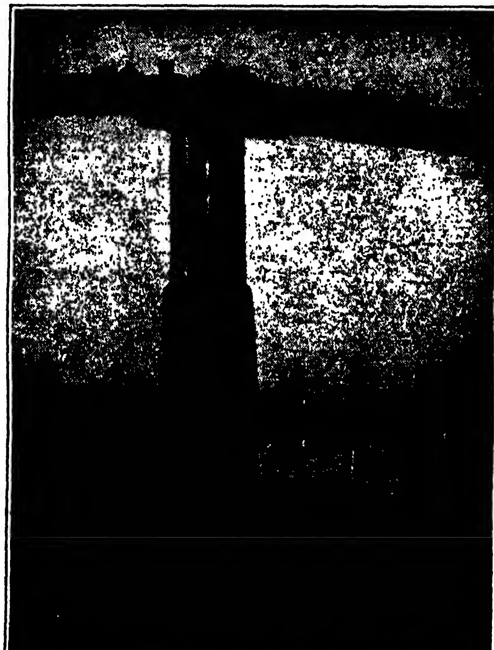
The Barbizon School. Perhaps it was Constable's love of Nature, simple, and devoid of all artificiality, that, about 1830, induced a group of French artists to declare war upon the generally prevailing classicism, and to settle down in the little village of Barbizon, in the Forest of Fontainebleau, in order to live in close communion with Nature, and to prove to the world that in landscape the picturesqueness of the subject counts for nothing, that a landscape need be neither classical, nor heroic, nor romantic, as long as the artist can grasp the spirit and the poetry of Nature, and express in paint the emotions aroused in him by its contemplation. "Truth is beauty, and beauty is truth" was the watchword of this group, whose leader was Theodore Rousseau (A.D. 1812–1867), Troyon, Dupré, Jacque, Daubigny, and Diaz being among the other prominent members; while Corot and Millet are so closely affiliated to the Barbizon school that they are generally counted as belonging to it. Corot strikes the most lyrical note of all painters. He is the poet of the twilight, dreamy and musical, and more occupied with the essence and fragrance of Nature than with solid matter.

Rousseau is far more impersonal, a searching student of form and structure, while Diaz connects the Barbizon men with the Romanticists. Troyon and Jacque are noted for their magnificent painting of cattle and sheep, and Millet is the painter of the life of the fields, the ceaseless toil of the peasant in his grim struggle with the soil that is to yield him the sustenance of life. "The Sower" and "The Gleaners" are fine examples.

DIDO BUILDING CARTHAGE, BY J. M. W. TURNER

He is a notable instance of that new beauty (as opposed to the classic beauty) that is to be found in passionate truthfulness to Nature—the beauty of character expressed by synthetic simplification.

Turner and the Sun. Just as the aims of the Barbizon men had been foreshadowed by Constable, so Turner discovered and turned to account the theories that were to be systematised subsequently by the French Impressionists. In his early work he favoured the heroic landscape; but, in his power of rendering sunlight, he is already at this early period immeasurably ahead of Claude Lorrain, his artistic progenitor, as may be gathered from a comparison of Turner's "Dido Building Carthage" and Claude's "Embarkation of the Queen of Sheba," which are hung side by side at the National Gallery. But if Turner recognised the actual appearance of objects bathed in light and atmosphere, the softening of the outlines, the vibration of the light, he did not apply his knowledge to the service of realism, of landscape "portraiture," as practised later by Claude Monet. He was an exalted idealist, a visionary, who knew how to clothe the glorious inventions of his imagination in real golden sunlight. Characteristic of his attitude is the answer he gave to one who remarked that he had never seen such colours in Nature as appeared in one of his own pictures: "Don't you wish you could see them?" The turning point in the master's art was his visit to Italy, and particularly to Venice. The wonderful atmospheric effects of the lagoon city left an indelible impression on his mind. Henceforth the actual view, the *objects* of the landscape, became quite secondary. The transparency and vibration of the atmosphere, the glory of sunlight, became the real motif of his pictures.



BATTERSEA BRIDGE, BY WHISTLER
in the National Gallery of British Art, London

What Impressionism Is. What Turner had achieved, as it were, instinctively, through sheer force of his genius—that is, the analysis of light—was put into what might be called a scientific theory by the French Impressionists, who, in trying to render in paint the full glitter and brilliancy of open-air sunlight, turned to account the results of the scientific research of Helmholtz and Chevreul and the revelations of spectral analysis. The full explanation of the theory of the decomposition of light into its constituents of coloured rays belongs to the sphere of optics. Here it is sufficient to explain that the *technical* reform of Impressionism—for the term embraces other reforms as well—consists of the employment of the primary colours only, which are used in alternate touches and in the right quantities, so that at a certain distance they blend and produce the desired effects. Thus, it is well known that green consists of a mixture of blue and yellow. If, instead of being mixed on the palette, these colours are applied in alternate touches, the effect upon the eye will be a green tone, but a green of far more vibration and greater luminosity than mere green paint. The Impressionist theory has frequently been carried to absurd extremes; but, in the hands of a master like Claude Monet, has yielded results that could not have been achieved by any other method. Of him it may truly be said that light is the one and only subject of his pictures, and nobody has ever come nearer to perfect truth in depicting the glitter and sparkle of sunlight.

Japanese Influences. To-day every country can boast of a large number of landscape painters whose work will live through the ages, but nothing new has been added to the history of the development of landscape art since the advent of Impressionism. Perhaps the next move will be in the direction of a more complete acceptance of the Japanese ideal, which has already exercised a certain amount of influence, notably on the work of Whistler. This Japanese ideal is the realisation by art of the universal soul or spirit which underlies the non-permanent, temporary, and therefore unreal forms of matter. The end is achieved by a very broad but exquisitely beautiful and decorative generalisation, which discards all that is not really essential to convey the idea intended by the artist. The attitude of the Japanese artist is pretty nearly reflected by Whistler's reply in a famous law case, when he was asked whether a picture of his produced in Court was a correct representation of Battersea Bridge—"I did not intend it to be a correct portrait of the bridge; as to what the picture represents, that depends upon who looks at it. To some persons it may represent all that was intended. To others it may represent nothing."

P. G. KONODY

Shape and Functions of the Spinal Cord. The Size and Weight of the Brain. Its Appearance, Development, and Functions.

THE SPINAL CORD AND THE BRAIN

We now approach the most difficult part of physiology—that borderland when it touches psychology, when body and soul and matter and mind meet; for the central nervous system, composed of brain and spinal cord, is the exquisite instrument that enables impulses of mind to be translated into movements of matter, just as a piano or organ materialises the musician's dreams into sounds of harmony. These centres, acted on by the mind and will, constitute the engine, or driving power, of the whole body; and the nerves just described are the connecting wires between those batteries of force and the machinery to be moved in the body.

The Spinal Cord. We will begin with the spinal cord, because it is the most ancient nerve-structure in the body, and the brain has been developed from it. It will be seen in the section on Biology how far the spinal cord carries us back, whereas the brain proper is of much more recent origin. According to our custom so far, we begin with the structure, and then proceed to the functions of the nervous system.

The spinal cord is a flattened cylindrical band of soft material, *eighteen inches long;* it is nearly one inch in diameter, and weighs about *an ounce.*

It is somewhat oval in shape, and on section is grey inside and white out. The cord is partly divided into right and left halves. All along it pairs of nerves are given off right and left, both in front and behind; and these pass out into the body between the vertebræ; while at the end the cord itself divides up into a bunch of white nerves called the *cauda equinæ*, because it is like a horse's tail.

Its Composition. The cord is really a tube, there being a small hole, or foramen, in the centre, running from end to end, lined with many ciliated epithelia. This tube is surrounded first by grey matter, then by white, and then by the membranes of the cord. These membranes are three in number, of the same name and similar in structure to those covering the brain; they will be fully described later on. The grey matter in the middle (seen on section) is somewhat in the shape of a butterfly with outstretched wings [**77**]. It consists of nerve cells and naked axis cylinders, and is rather pink, because four times as much blood circulates in it as in the white matter. The white matter of the cord consists of medullated nerves, blood-vessels, etc., all embedded in neuroglia (a close network of fibres). Grey matter consists of four-fifths, and white matter three-fifths, of water.

Its Work. The white matter gets less and less from above downwards, as the nerves composing it become fewer, while the grey matter suddenly enlarges at the spots where the nerves of the arms and legs are given off, there being here a large increase of nerve cells owing to the great activity in the cord at these points. Only about half the spinal nerves that enter the cord pass into the brain, a large number terminating in the grey matter.

The spinal nerves come off in 36 pairs between the vertebræ, leaving the cord on each side by two roots, anterior and posterior. The anterior pass out into several bundles from the front of the grey matter of the cord, and are *efferent*, or *motor*, as is proved by the fact that all motion ceases in the part they supply when they are cut, while sensation persists. The posterior roots come off from the back of the grey matter in one large trunk, and shortly after they leave the cord, and before they join the anterior, they pass through a ganglion, or a swelling, composed of nerve cells on the trunk [**76**]. These are *afferent*, or *sensory*, in character, as is proved by the part they supply losing all feeling when they are cut, while it still retains its powers of motion. The function of the ganglia has been explained in the section on Nerves to be that of nutrition.

Course of the Nerves. The course of the nerves in the cord is threefold:

The afferent or sensory nerves, entering at the back, ascend to the brain along the posterior and lateral segments of the cord.

The efferent or motor nerves, leaving at the front, descend from the brain along the anterior and lateral columns.

The third class, those terminating or originating in the cord, constitute, as we have said, nearly half the entire mass.

One point should be noted, and that is that both motor and sensory fibres cross to the opposite sides—the motor fibres at the top, just before they enter the cord, and the sensory at the level with the cord, where they join after passing through the ganglia.

The centres of nutriment for the motor nerves are in the brain proper—any degeneration in them extends downwards; whereas, as we have seen, the nutritive centres for the sensory nerves are in the ganglia, or the posterior roots, and any degeneration in them extends upwards.

Three Functions of the Spinal Cord.
1. Conduction. The spinal cord is largely made up of fibres that conduct impressions or impulses either of sensation up the cord to the brain by the posterior part, or of motion from the brain down the cord by the anterior part. The *sensory* nerves cross over to the opposite side of the cord as soon as they enter it; the *motor* fibres do so before they leave the brain in the medulla oblongata; so that the right half of the cord contains the motor fibres of the right half of the body, and the sensory fibres of the left half, and vice versa.

2. Reflex Sensation. A good instance of this is when disease of the hip occurs, and the sensation of pain is felt in the knee. The sensory nerves of the hip and knee both run to the same part of the cord, and the sensation from one part is reflected to another.

3. Reflex Action. This is like that of the

76. HOW THE NERVES JOIN THE SPINAL CORD

medulla, an action quite outside consciousness, and the necessary result of a certain irritation.

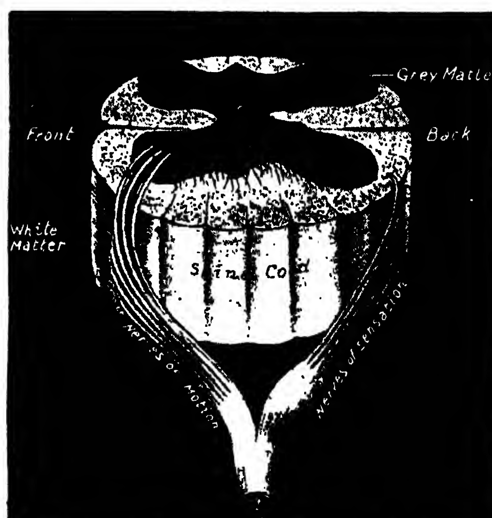
Movements may even have a definite purpose, like the beating of the heart or breathing, and yet be reflex, and without any exercise of conscious mind. Purpose in reflex action does not so much show the intelligence of the creature as of the Creator. One of the best instances of reflex action in the spinal cord is the knee-jerk, when one leg is crossed over the other, and allowed to hang loosely down. If the knee be struck below the knee-cap with the edge of the hand, the leg is at once kicked out, not only without the wish of the person, but even against it, so that the strongest will cannot prevent this reflex action from taking place. That this action is produced by the spinal cord is clearly proved, because if it be diseased at a certain part the leg no longer moves, however violently the knee be struck.

The Size and Weight of the Brain. We now turn to consider the brain, which forms in adults $\frac{1}{40}$th part of the weight of the body (in babies $\frac{1}{10}$th); in elephants it is $\frac{1}{500}$th, and in whales $\frac{1}{3000}$th part. The weight of the average male brain is found to be about $49\frac{1}{2}$ oz. An idiot's brain may weigh as little as 16 oz., while a scientific man's (Cuvier's) may weigh 64 oz. Weight of brain does not, however, always mean great intellect, for a washerwoman's healthy brain has weighed as much. At three years old the brain is $\frac{6}{7}$th of its full size; at twelve, $\frac{9}{10}$th; at fourteen it reaches it, though the development of functions may go on to forty. After forty the brain loses about an ounce in weight every ten years. The brains of women are about 5 oz. lighter than those of men, mainly because the whole body is generally smaller. The brain of the larger apes weighs under 1 lb.

The Rhythmic Movement of the Brain. The first thing to be observed, if part of the skull-cap could be removed during life, is that the brain inside is continually moving. It throbs like a heart. If we put a finger on the membrane, or watch it and count the beats, we find they are just the same as the pulse. This movement of the whole brain is very remarkable. We do not *feel* it ourselves, unless it be very excessive, and then we say the brain throbs, or seems too large for the head. This throbbing is caused by the numerous blood-vessels that run everywhere in the soft, yielding cerebral substance; and as all these arteries beat with the heart, they move the whole brain up and down in rhythm.

Turning from the brain to the inside of the skull-cap, we observe many channels and depressions grooved deeply in it, for the larger veins on the surface of the brain to run in. The brain itself cannot as yet be seen, as it has no less than three membranes, or *coverings*, over it, and the outer one is very thick and opaque. It is called the *Dura Mater*.

The Outside Covering The Dura Mater (or Hard Mother) is so called because it is a rough, hard, and unyielding covering of the brain. Its outer surface is very rough, and adheres closely to the bones of the cranium, of which it forms the periosteum (bony tissue), while at the margin of the great hole for the spinal cord in the occipital bone it is continued downwards to form the outer covering of the cord, being, however, only loosely attached to the vertebræ. Its inner surface is smooth and glistening. It is made of a similar material to the white of the eye. It forms also the outer sheathing of the various nerves that pass out



77. A SECTION OF THE SPINAL CORD

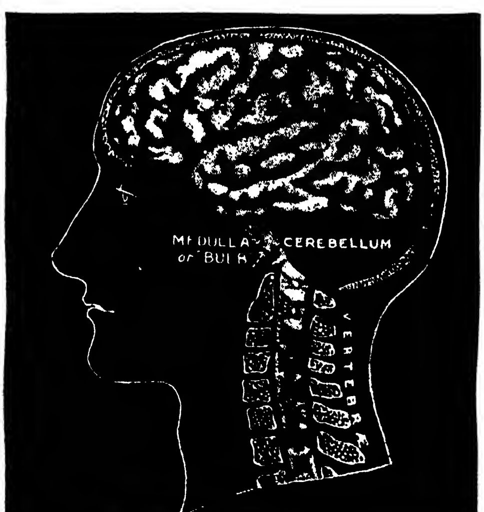
of the brain, and inside the skull the layers separate and form fibrous tubes, which are used as veins for the return of blood from the brain. The arteries that run on its surface are very numerous, and all help to supply the brain. The Dura Mater sends a strong arched division down, like a sickle, between the two halves of both the

greater and lesser brains, stretching from before backwards; and also a horizontal layer between the lesser brain below and the greater brain above.

The Middle Covering. The Arachnoid (or Spider) membrane is so called from its delicate structure, resembling a spider's web. It is a closed and empty bag, consisting of two layers, and the brain is folded up in it. The outer layer rests against the Dura Mater, and the inner one against the third membrane of the brain. At the base of the brain a good deal of fluid often collects in the cavity, and thus forms part of the "water-bed" on which the brain rests. The main bulk of the fluid lies, however, *between the Arachnoid and the innermost membrane*, in the space between the two. This fluid is watery, slightly saltish in taste, and is called cerebro-spinal fluid; it is very like lymph, and is the drainage of the brain.

The Inside Covering. The Pia Mater (or Pious Mother), the innermost membrane of the brain, is so called because it takes such excellent care of the valuable organ—the brain—within it. It is a single layer of very fine membrane, holding together a perfect meshwork of blood-vessels that spread in all directions over the surface of the brain. It dips down between all the convolutions, and adheres closely to the brain substance beneath, though quite loosely to the Arachnoid above.

The Brain. When these three membranes are stripped off, the cerebrum, or brain, is seen beneath as a soft mass nearly 3 lb. in weight [79]. If we carefully take the brain out of its bony case, and examine it minutely, we notice at once certain features. In the first



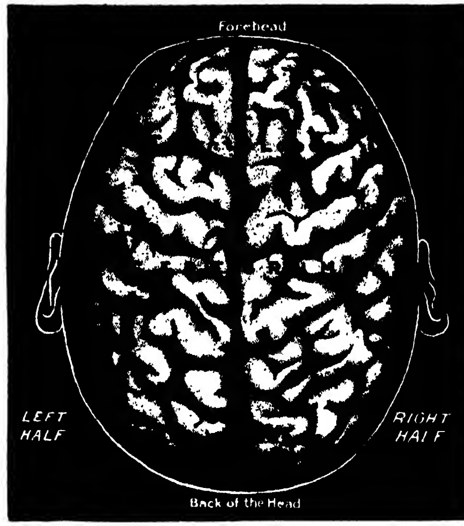
78. A SIDE VIEW OF THE BRAIN AND SPINAL CORD

place, there are two brains—the larger one, the cerebrum, in front and above; and the little one, the cerebellum, below and behind—the one as big as a melon, the other the size of a small orange. A girl's head with part of her hair done in a small knob behind very much resembles these two brains.

The cerebrum is divided by a cleft down the middle into two halves—right and left. The two halves appear exactly alike, and are joined together by a *broad band of white matter* about the centre of the cleft, called the *Corpus Callosum.*

We next observe that the large brain may roughly be divided into *three regions, or parts.*

The upper part, which includes all the surface



79. THE LOBES OF THE BRAIN VIEWED FROM ABOVE

of the brain, or *cortex*, is a mass of convolutions looking just like a number of snakes twisted together. Between the folds of these convolutions the Pia Mater dips down, carrying the blood-vessels. These folds are very intricate, and run in all directions. If the surface of the brain were flat, it would not be a quarter of the extent it is when folded up in convolutions. The folds not only enormously increase the superficial area, but are probably connected closely with mind-power, for, the cleverer a man, the deeper and more numerous they seem to be. In a child they are comparatively few and shallow, but rapidly increase with age and education.

The mid brain is quite different. It includes all the central part and under surface of the cerebrum, and consists of masses of nerve substance—two in front, called the *Corpora Striata*, and two behind, the *Optic Thalami.*

The lower brain is called the *Medulla Oblongata* (or oblong marrow), and connects the large brain with the smaller brain, or cerebellum, behind and the spinal cord below. It also is partly divided in two, and contains a long, hollow space (the fourth ventricle), and several small masses of nerve-matter the size of peas.

There are also several other ventricles, or empty chambers, in the brain—one being as much as 4 in. long—with channels leading from one to another.

What the Brain Looks Like. If now, with a large, sharp knife, a horizontal slice is taken completely off the cortex, we get a very good view of the wavy external border of grey substance following the outlines of the convolutions,

and looking just like the shaded margin that used to indicate the coast-line in all old maps.

The Empty Spaces in the Brain. If a second horizontal slice be cut right down to the connecting band of white fibres, we get a still better view. The whole of the brain so far is *quite solid* and soft, like the curd of milk, white inside, and grey round the edges. The next slice will cut through the roofs of *two* of the five caverns, or *ventricles*, of the brain which have long extremities like horns, and lie on each side of the connecting band and in the centre of each hemisphere. Their peculiar shape and the rounded masses rising inside them are very curious, and their use is not fully known. The other three ventricles are in the base of the brain and medulla, and are very small. Beneath the two lateral ventricles we reach the mid brain and the four large masses of nerve matter, two—the Corpora Striata—connected with motion, and two—the Optic Thalami—with sensation. Behind these, again, are four little bodies—the *corpora quadrigemina*—like four white peas, where the nerves of sight terminate.

The Lower Brain. Perhaps we may get a clearer grasp of the divisions of the brain if we follow them upwards from the spinal cord. When the cord reaches the brain it spreads out and flattens and divides from the back so as to be spread open like a split herring: this is the medulla, or lower brain, underneath [81]. Across the front is a broad band of fibres known as the *pons*, or bridge, which, passing upwards on each side, is connected with the little brain, or cerebellum, which rests on the medulla above. Beyond this bridge of fibres the medulla divides into two great pillars—the *crura cerebri*—which pass up to the mid brain, each forming therein the two masses of grey, nervous matter we have seen—the Corpus Striatum in front, and the Optic Thalamus behind. From these masses two bands of fibres pass upwards and are folded backwards, right over the mid brain, forming eventually the two cerebral hemispheres and all the convolutions of the cortex in the upper brain.

The Five Lobes. There are five lobes in each half of the cortex—the *frontal* in front; the *parietal*, or middle lobe, separated from the former by the great *fissure of Rolando;* then the *temporal*, at the side, also separated from the first by the *fissure of Sylvius*. The *occipital* is behind, and is separated by the *parieto-occipital fissure*. In the centre is the fifth lobe, known as the *Island of Rheil.*

About 2 in. down between the hemispheres, or slightly separating them, can be seen the broad white band of fibres that connects one side with the other (*Corpus Callosum*). We will now look at these three divisions and the cerebellum a little more closely. If the convolutions of the cerebrum be examined in the upper brain, or cortex, they will be seen to have a grey appearance, and, if cut, it will be seen that there are several very thin layers of grey and white matter alternately for about ½ in., and then the inside of the convolutions and the whole cerebrum are pure white. The depressions between the convolutions are about an inch in depth. Although the exact shape of the convolutions varies in each individual, just like the features in the face, yet there is always a general plan followed, so that the leading elevations and depressions have all received special names.

Organs of Smell and Sight. At the base of the brain and in front we see embedded in the under side of the hemispheres of the cerebrum the two nerves of smell (olfactory bulbs) as they proceed forward to the nose [80]. They consist of two large masses of grey matter that receive the impression of odours, and two large white nerves that carry the sensation to the brain. Further back you see two larger nerves crossing each other from right to left, and running backwards into the brain. These are the two optic nerves, or nerves of sight.

The Medulla. The medulla is somewhat pyramidal, or conical, in shape, and is not more than 1 in. long, It is the upper expanded part of the spinal cord within the brain. At the upper part it is crossed by a broad band of fibres known as the *pons varolii.* The cerebellum that rests upon the medulla is about 4 in. by 2½ in. and 2 in. thick, and consists of a body and three pairs of bands, or crura, two upper ones connecting directly with the cerebrum, two forming the bridge, or pons varolii, and two connecting behind with the medulla direct. The surface of the cerebellum is not in convolutions like the cerebrum, but is in fine vertical plates, all being grey outside and white within, the arrangement or section being in branches, like a tree.

The Nerves in the Brain. The nerves in the brain have been grouped generally into three great divisions:

1. Those that connect every part of the cortex of the hemisphere with the great ganglia of the mid brain (corpora striata, optic thalami, and the corpora quadrigemina), both motive and sensory.

2. Those that connect every part of these ganglia with the lower brain or medulla, and the spinal cord, both motive and sensory.

3. The peripheral nerves that leave the spinal system and form the nerves proper.

The grey matter of the brain is composed of a basic substance—neuroglia—and closely packed cells of every shape and size, with an interlacing network of naked axis cylinders.

The white substance is one mass of medullated nerves passing to and fro in all directions.

How Blood Feeds the Brain. The blood supply of the brain is of a special nature. The total amount passing through the brain is not very great, but five times as much circulates in the grey matter as in the white, the former being the true centre of metabolism in the nerve cells connected with the action of mind. There is probably a controlling centre in the brain for regulating its own blood supply. If this does not act well, any sudden change in the position of the head causes dizziness, or vertigo. The arteries leading to the brain are exceedingly tortuous, thus by mechanical means lessening

the force of the heart's beats;. and there is a circle of arteries at the base of the brain (the *circle of Willis*) to ensure a free supply to all parts. Large lymph spaces exist round the arteries, so that when these expand they do not press on the brain substance.

The large veins are not true veins, as they contain no muscle fibre, nor valves, but are open channels, called sinuses, formed by the bone and Dura Mater, and can neither be compressed nor distended. Besides moving with the heart, the brain rises and sinks a little with respiration.

We have examined generally the structure and leading divisions of the central nervous system, and will now consider the respective functions of the different parts.

The Cortex. The surface of the hemispheres, or cortex, is believed to be in a special way the seat of the conscious mind or spirit of man. The convolutions represent the extent of his faculties; the more numerous and deeper they are, the more extended are these. It is probably here, too, that memory lays up her stores of knowledge. As actions arising from cortical excitement are voluntary and intelligent, and the direct result of the conscious mind, nowhere do we find greater evidence of the value of education than in this region. It is mainly composed of brain cells, though the nerve fibres are quite innumerable.

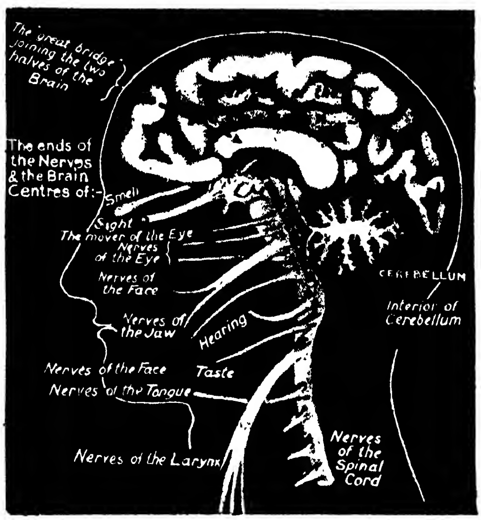
The Medulla Oblongata. The lower brain, or medulla oblongata, is the centre of the passive or inner life of the body.

The medulla is, of course, largely composed of white nerve fibres passing up to the brain, but it is also the controlling centre for the most important and vital actions of the body. Here is the centre that controls *respiration*, that controls the *swallowing of food*, the power of mastication or chewing, the *formation of saliva*; every one of these so far, it will be seen, is connected with the supply of food to the body. It is also the centre for *regulating the action of the heart*, and the *size of the blood-vessels*, especially of the skin. Under fear or cold it contracts them, and we become pale; under shame or heat it expands them, and we blush. It also contains centres for *regulating the size of the pupil of the eye*, for *taste*, and for *hearing*, and for some of the mechanism of *speech*. The medulla, together with the cord, is the centre of what is known as pure reflex action.

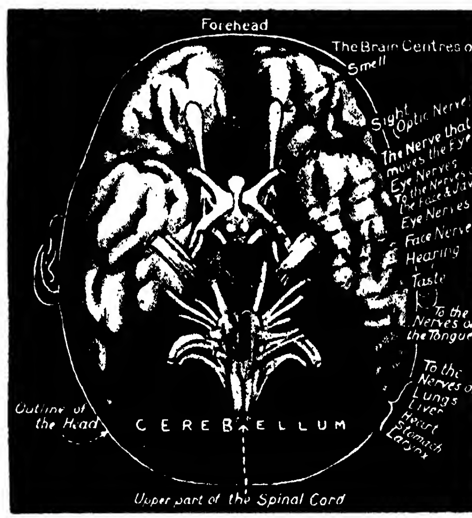
Why We Yawn. Nerve currents from the lungs and other parts are sent to the medulla when the blood contains too much carbonic acid; the blood itself circulating in the medulla also irritates the respiratory centre so that a reflex action occurs and force is transmitted to all the muscles concerned, causing a deep inspiration to purify the lung. This automatic—or more properly reflex—action may easily be proved by experiment. It is called reflex because it is, as it were, reflected back again, like a ray of light from a mirror.

The action of the medulla is under the control of the unconscious part of the mind, and it is therefore closely connected with the sympathetic system, which acts entirely without our knowledge. Of course, the value of this sort of action is immense. Were it not for this system, life could not go on, for we could never carry on the processes of life as conscious and voluntary acts with the regularity and accuracy they require. We shall see the great value of reflex actions again.

The Cerebellum. The cerebellum is the site of the organ of equilibrium, and enables us to stand erect. It thus co-ordinates, or causes to act together, certain groups of muscles for this purpose. When diseased or paralysed, as by alcohol, a man can no longer stand upright.



80. THE RIGHT HALF OF THE BRAIN AND THE NERVES FROM THE MEDULLA TO HEAD AND TRUNK



81. THE BRAIN VIEWED FROM BELOW, SHOWING THE RELATION BETWEEN THE THREE DIVISIONS

Certain parts of the brain are specialised for a particular function, and the brain never acts together as a whole. The faculty of speech, on account of the interest which attaches to it, is a very good illustration of this fact.

The Centre of Speech. The centre of speech is situated just above and in front of the *left* ear. It is not on the right side at all. Here is the part that enables us to utter our thoughts, and from which power is given to the centres for the muscles of the mouth, throat, and tongue to formulate ideas into words. A blow here, of sufficient violence, perhaps depressing the temporal bone, or a disease of this part inside, would render a man speechless, whereas the same blow on the right side of the head would have no such effect.

But a blow of this force would most likely be followed by a further effect. The nerves of the body, as they travel to the brain, cross over from left to right, and right to left. So that the left brain, which is far the more developed, rules the right half of the body, including the right hand.

How the Right and Left Halves Differ. A blow of sufficient violence to injure the centre of speech would probably also paralyse the right half of the body, including the arm and leg. It is therefore a rule amongst medical men that if a man be paralysed down the right side, he is probably speechless as well. Whereas, if he be paralysed on the left side, his speech is uninjured, because then the injury is on the right side of the brain.

But there is a remarkable exception to this. Certain people in the world are *left-handed*. That is, all that other people can do with their right hand they can do with their left. This is not the result of bad training, but it is *from birth*. The reason of the difference is that the two sides of the brain are transposed; the *left* brain is on the *right side*, and the *right brain* on the *left*. One finds, occasionally, the heart on the wrong side of the body—that is, the right-hand side—in the same manner.

Now, these left-handed people, having their brains transposed, speak from the right side of the head, not from the left. If a violent blow be struck them on the left temple the right side of the body may be paralysed, but they will be quite able to speak; whereas a blow on the right temple will not only paralyse the left side, as it does generally, but it will also render them speechless. There is one more curious fact as to speech. People who have been known to have the centre of speech incurably diseased or injured on the left side may, after some time, slowly regain the power of speech and begin to talk again. It is believed that the right brain is, to a great extent, held in reserve to supplement the left, and that in such cases the right side slowly and gradually takes over the duties the left can no longer perform.

Natural and Artificial Reflex Action. We have already seen instances of natural reflex action, and of what importance they are to us. So valuable are they, indeed, that during the whole of our lives we are increasing the number of such acts; doing more and more complex movements without the aid of consciousness, and thus adding to those reflex acts which are born in us numbers of others which are artificial or acquired. It is probable that, as the lowest part of the cerebrum is the principal centre for *natural reflex action*, and the highest part for purely intellectual or voluntary or *intelligent action*, so the mid brain is a great seat of *actions* once voluntary, but which have *become reflex*.

At first, nearly every action is the result of direct will and mental effort. Watch a child learning to walk. It is as hard as learning Greek is to us; each step is considered and taken with great difficulty. In six months, however, it has so become a matter of habit as to be reflex—that is, to be conducted outside conscious will action, and the cortex is set free from thinking *how* to walk, which absorbed it at first, to consider *where* to walk to, or to direct intelligently this new reflex habit. The same occurs with reading and writing in early life, and every other oft-repeated act.

At first, all the mind is concentrated on *how* to read and *how* to write—*what* is read or written is of small importance. It is the connecting of certain letters with certain sounds, and certain sounds with certain shapes, that is at first such a severe mental effort; and yet so easy does it become by frequent repetition that after some time we never think of the separate letters, even when we write them, but writing and reading become acquired reflex habits, the mind being wholly absorbed in what is read or written.

Acquisition of Good and Bad Habits. This leads us to another point. A natural reflex action *cannot* be overcome; an artificial reflex habit can be overcome, but it is *very hard*. Swearing, for instance, soon become an artificial reflex habit, and the mind never thinks of it at all. An oath comes out at slight provocation, and we may not even know that we have sworn. To break such a habit is very difficult; and once we have allowed an action to become a reflex habit it is one of the hardest things in the world to conquer.

Three Actions of the Brain. The actions of the brain are therefore three in number:

1. Voluntary and Conscious, always proceeding from the cortex, which may be merely abstract action of the thought centres or the purposive physical replies to sensations of light, sound, or common feeling.

2. Acquired or Artificial Reflex acts, which are mostly unconscious and connected with the mid brain, and largely consist of actions purely voluntary which by continual repetition have passed out of consciousness, and are no longer sent up to the cortex, but are short-circuited in the mid brain.

3. Natural Reflex actions entering outside consciousness, and connected with vital physical processes, and mainly centred in the lower brain, or medulla, and the spinal cord.

A. T. SCHOFIELD

Choosing Stock. The Points of a Dairy Cow. Food and Feeding. Calf-rearing. Future of the Cattle Industry.

CATTLE REARING & MANAGEMENT

Domesticated cattle in the United Kingdom are reared with the two special objects of milk and beef production. Which of these two commodities it will pay the farmer best to provide depends very largely on the circumstances in which he is placed.

Environment a Factor in Stock-rearing. Questions of soil, climate, situation, marketing facilities, cost of production, and the value of the finished article must all be taken into consideration in determining what course it is best to adopt. In the vicinity of large towns and also in thickly populated districts—as in North Cheshire, South Lancashire, and the home counties round London, where the land is suitable for dairying—the new-milk trade will probably pay better than anything else. On dairy farms in more remote parts of the country, especially where there is a large surplus of summer milk, the manufacture of cheese, although involving extra labour, will generally prove the more remunerative. Butter-making will answer where there is a good market, but the price has ruled so low of late years, largely owing to competition with Denmark and other foreign countries, that many farmers have given up the production for some better-paying branch.

In districts where the conditions are suitable, feeding for beef takes the place of dairying; thus, on the rich feeding lands of the English Midlands and some other parts of the country the staple industry is the grazing of bullocks during the summer months when there is a flush of grass. On large arable farms it is often the custom to feed a number of beasts in stalls and yards during the winter with the double object of converting the roots and fodder grown on the farm into cash in the form of beef, and, at the same time, of treading down the straw into manure for use on the holding.

In other cases, especially in hilly districts, stock-rearing with a view to providing for the future wants of the grazier and the dairyman is the chief industry. It will thus be seen that the British live-stock industry is a very varied one, involving a number of interests, and anyone starting farming will have to consider very closely the local conditions before deciding which branch it will pay him best to follow.

The Selection of Stock. In purchasing and selecting stock in the market for any particular purpose the farmer and dealer generally make their choice by the aid of an instinctive and, in some cases, a marvellous knowledge, handed down to them by their fathers, of the good and bad points of cattle. If asked by the uninitiated why one animal is better than another, or why they know that one animal will feed quicker than another, they will often be unable to explain; but the fact remains that the appearance of the animal gives them an intuitive impression of its qualities.

There are indications, however, as in the case of other animals, that will give the careful observer some idea as to the feeding or milk-producing qualities of any particular beast. Thus, the power of any animal to make the best use of its food in assimilating nourishment for the production of fat in a beast intended for feeding, or for the manufacture of milk in a dairy animal, will depend very much on its possessing large and healthy digestive and respiratory organs. A wide and deep chest and a capacious barrel are, therefore, to be looked on as indications of an animal's ability quickly to secrete fat. This property is also shown by a fineness of the bones of the extremities in the head, limbs, and tail, and an animal showing coarseness in these points should be passed over. Another very important point is the touch; and if a portion of the skin over the ribs on being raised between the thumb and forefinger feels soft, mellow, and elastic, it is a sure sign of the property of secreting fatty tissue. A hard, inexpansive skin shows a slow feeder.

How to Tell Good Feeders. The following may be taken as the chief indications of the qualities of feeding in cattle.

Head and Neck. The head should be fine, not coarse; broad between the eyes; the face moderately short, with the muzzle broad and dewy. The horns should be fine, varying according to breed; the ears full and sensitive; the eyes clear and mild. The neck should be clean, large where it joins the shoulders and breast, and tapering to the head.

Fore Quarters. The chest should be wide and deep, with the breast projecting well in front of the forelimbs; the shoulders broad, neat, and open, giving a good width over the crops.

Body. The girth behind the shoulders should be large; the back and loins straight, wide, and flat from chine to rump; the ribs well arched and deep.

Hind Quarters. The hook bones should be well set and nearly on a level with the backbone; there should be a good length from the hook bone to the pin bone, so as to form a long, broad, and straight quarter; the tail head should be on a level with the back and broad, the tail itself tapering toward its extremity; the twist or inner thigh should be full and large.

Legs. The legs should be short and well fleshed to the knee or hock, but below the bone should be fine and flat, and the hoofs small.

Skin. When handled, the skin should be

mellow and soft to the touch, and should at the same time be covered with soft hair.

A careful study of the above points will give the intending purchaser some information with regard to the future feeding properties of a store beast; but it must be remembered that it is always more difficult to be a judge of store cattle than it is of fat ones. The fact that an animal is fat and ready to go to the butcher is generally apparent to the observer, although some skill is required in forming a correct judgment as to quality; but in the case of purchasing store beasts one has to judge their future capabilities from present appearances.

The Choice of a Dairy Cow. Most of the foregoing points would also equally apply in the case of the selection of a dairy cow, especially one required for dual purposes. The head, however, might be somewhat longer and tapering towards the muzzle; the width of the chest also is not so essential, although it should be of sufficient capacity to prevent any tendency to lung disease. The barrel and belly should be capacious, so as to allow of a large and well-formed digestive system, which is essential for the assimilation of nutriment. The hind quarters are most important, and a good length from hook bone to pin bone is particularly necessary to give the length in quarter required for supporting a capacious udder. When viewed from behind, the legs should be well apart, leaving plenty of room for a good udder between, and the cow should have a general broad appearance from this aspect.

The udder should be square and neatly formed; not necessarily very large, but well set on behind, and coming well forward, with four good-sized teats nicely placed so as to allow plenty of room for milking purposes. It should not be too pendulous or pointed, should be free from fleshiness, and the skin when handled should be soft to the touch and covered with a network of fine veins. The hair should be silky and not excessive in quantity. Well-developed milk veins—that is, the large veins on the under side of the abdomen which convey the blood back from the udder—are looked upon as a good indication of powers of milk production.

A good type of dairy cow should, therefore, be recognised by a soft skin, clear and mild eyes, a somewhat narrow and elongated head, and an udder of large size, but well placed and of sufficient muscular strength to prevent it from being baggy or pendent. The milk veins coming from each side of the udder should also be well developed.

Determination of Age. The age of cattle can be told by the appearance of the horns and teeth. Advantage is taken of the changes in the incisor teeth in the lower jaw for this purpose, the permanent teeth as produced being much broader in appearance than the milk teeth they replace. Thus, just before the ox is two years old, the two central permanent incisors make their appearance; at about two and a half years old the next pair, or the "middles," come through; at three years the "laterals" appear, and at three and a half years old the "corner" incisors are through. These indications will be useful when there is any doubt as to the age of an animal. It must be remembered, however, that in well-bred cattle the development of the teeth is earlier than in inferior animals. Again, as the age increases the teeth become worn, and continue to shorten, and apparently to separate from each other; this fact is a further guide.

As regards the horns, a small but distinct ring is formed at the base at three years old, when a heifer generally produces her first calf. A similar ring is then formed each succeeding year until the animal is ten years old, when the circles get rather confused. Unscrupulous dealers will sometimes obliterate the marks on the horns, but taking the number of nicks on the horns and the appearance of the teeth together, there should be little difficulty in determining the age of an animal.

Breeding. In the ordinary management of domesticated cattle the milking period begins with calving, after which the yield of milk rises slightly for a few weeks, and then falls off gradually till the cow is dry. In Nature, spring is the time of the year for young animals to be born, when there is every prospect of an ample supply of food for mother and offspring during the coming growing period. This is still followed in a good many districts, especially on cheese-making farms where a large flow of milk is required for the summer, and also in the case of many of the beef breeds. On milk-selling farms, however, where a supply of milk has to be maintained all the year round, arrangements have to be made for this purpose, and it is found necessary to calve cows in the late summer and early autumn to provide for the winter dairy.

We must remember that the power of production of milk has been greatly extended under domestication, and that a cow gives a larger yield, and for a longer period, than she would in the wild state. Moreover, in ordinary circumstances she will soon be in calf again, so that, during the greater part of her milking period, not only has she to provide for a large flow of milk produced under artificial conditions, but also to repair the ordinary wear and tear of her system, besides nourishing her special condition. If a cow is subjected to bad treatment and poorly fed, not only will her own constitution be undermined, but the future life of the calf will be seriously affected. It is, therefore, essential that care and intelligence should play an important part in the breeding and management of dairy stock on rational lines. These remarks do not apply to beef breeds reared under more natural conditions.

Calf-rearing. Nature's method is for the calf to suck the cow, and this is best as far as the latter is concerned, being followed with some of the poorer milking breeds, such as Herefords, Galloways, and Highlanders. Pedigree calves, especially bulls, in other breeds are also frequently allowed to run with their dams. Again, where calf-rearing is the principal object, a cow with a good flow may be made to rear two calves at the same time, and when these have been weaned, a second pair may be put to the cow. On most farms, however, milk is too valuable an article for feeding calves, and they have to be reared on some artificial substitute in the form of calf meal. The usual method is to allow the calf to suck its mother for the first few days, when the milk—then known as colostrum—is of special composition, and of no use for commercial purposes. The calf is then removed, receiving new milk for a day or two, and this is gradually changed into a diet consisting of separated milk made up to the standard of whole milk by the addition of some substitute.

When the calf is taken away from its mother it should be fed from a bucket, preferably, three times a day with new milk, the allowance gradually rising to about two quarts at each meal. At the end of a week or so a gruel made with calf meal should be worked in by degrees, thus reducing the quantity of milk. Separated, or skim, milk, which possesses considerable feeding value, should, if available,

THE CATTLE ON OUR ENGLISH PASTURES

STUDIES BY THE POPULAR ENGLISH CATTLE PAINTER, SIDNEY COOPER, R.A.

1887

gradually take the place of the new milk, and be used for mixing with the gruel. On milk-selling and cheese-making farms, where there is no separated milk, whey or water must be used in making the gruel.

At the end of a month the calf will be on a diet of warm gruel, given in three feeds daily, consisting of one to three pounds of calf meal, according to its strength and whether separated milk is available or not. About this time a little sweet hay may be put in the rack for the calf to nibble at, and dry food, with a little linseed-cake, may be gradually substituted while the gruel is reduced, the midday meal being stopped first. When about six weeks old, calves may be turned out to grass in summer during the day, and will soon learn to graze; but it is advisable to give them shelter at night. Weaning should take place when the calves are about five months old, the gruel being then finally stopped.

In some parts of England, especially in the North, the calf is removed immediately it is dropped and before the cow has time to lick it. It is then fed for the first week on its mother's milk, given warm, and for the next few days on new milk, not necessarily its mother's. The subsequent treatment is similar to that recommended in the former case. It seems questionable whether this method is as good for the cow as the more natural one of allowing the calf to suck its dam for the first few days.

Substitutes in Calf-rearing. Substitutes in calf-rearing may be divided into: (1) Cream equivalents, to take the place of the fat removed from separated or skimmed milk; and (2) milk substitutes, or calf meals, to take the place of whole milk when made into a gruel.

The following substitutes for fat may be used with good results, namely, cod-liver oil, pure linseed, and pure linseed-cake. The first of these may be fed at the rate of two ounces per calf per day, being stirred into the separated milk, but it must be remembered that great harm may be done by a careless use of the oil.

There are many excellent patent calf meals and cream equivalents now on the market at a reasonable price, and in the majority of cases it will pay to use these, unless a large number of calves are being reared. A safe home made calf meal can be made as follows: Oatmeal, 2 parts; linseed-cake meal, 2 parts; pure crushed linseed, 1 part. A small quantity of ordinary flour or arrowroot may be added to counteract any tendency against scouring.

Rearing After Weaning. Calves, after weaning, must be kept under cover the first winter, and the run of a good covered yard will be found most useful for this purpose. They must not be allowed to lose their flesh, and should receive a liberal ration, consisting of a few roots, sweet hay, and a mixture of about $1\frac{1}{2}$ to 2 pounds of linseed cake and meal each day.

At the end of the winter yearling steers and heifers may be turned out on to good grass, and they will then graze, with no extra food, during the summer, and should come in in good condition towards the autumn. During the second winter they should receive roots, hay, and straw, together with an allowance of cake and meal. For those intended for *early beef* the ration should be gradually increased until they are ready for the butcher at twenty to twenty-four months old

The yearlings which are run through the second winter as stores may be turned out to grass in the following summer, and then taken up towards the autumn, and fed for winter beef when from two to three years old. Bullocks run on as stores till three years old may be grazed fat on feeding pastures during the fourth summer. Heifers intended for breeding should be only kept in store condition and put to the bull when they are about two years old, so that they will calve down before the end of the third year.

A Mistake in Rearing. One of the principal mistakes in stock breeding lies in allowing the young animals to lose all their condition during the first, and especially during the second, winter, for there is then immense loss in food and time in making up this wastage before the animal is fit for the butcher. A secret of success in modern farming is never to allow the calf flesh to be lost, and to keep the young animal steadily going on till it is ready for the block. In the case of heifers, to allow them to get into too poor a condition is sure to act detrimentally on their first calf, to say nothing of the effect this will have on the value of the heifer herself if intended for the market; and here, again, trying to save a few shillings during the rearing period will be found a penny wise and pound foolish policy.

Summer Feeding. It is commonly estimated that three acres of grass land are necessary to keep a cow for the year, providing pasturage during the summer and hay for winter feeding. As a matter of fact, with good grass land rather less would suffice, and this is also the case with farms which are partly arable, and where crops are specially cultivated for use in the dairy. Thus, where there is a certain amount of arable land connected with the holding, a greater number of cows can be kept on the same area, especially during the winter.

During summer, cows are kept on pasture, which is excellent for inducing a flow of milk, and consequently at this time of the year milk can be produced at a cheaper rate than at any other season. The price of milk is, therefore, lowered in milk contracts during the summer months, and the farmer, who has no difficulty in getting rid of his winter milk, very often finds himself saddled with a large surplus supply during the growing season which he can only dispose of at a miserably low figure. It seems a pity that farmers in grass districts where they are subject to a summer glut of milk do not combine to start cheese factories which would take all the surplus supply, and thus prevent the price of fresh milk at this season from dropping to an unremunerative price for the producer.

Towards autumn, when the grass is less nutritious, and tends to go off in quality, it is a good practice to allow a small quantity of undecorticated cotton-cake—say, 2 to 4 pounds per head per day, which, besides adding to the feeding value of the ration, tends to check any undue laxative effects of the grass on the cows at that season.

Winter Rations. Before the advent of the turnip and its present method of intensive cultivation in rows, cattle were wholly dependent on the hay and straw grown on the farm for their sustenance during the winter, and consequently feeding with a view to fattening at this time of the year was impossible.

With the introduction of the turnip, swede, and mangel as winter foods, matters were considerably improved, and when linseed-cake was added winter feeding on modern lines came into practice. But the great advance was made toward the end of the nineteenth century, when cotton-cake and maize were added to the common feeding stuffs of the farm, and these were shortly supplemented with by-products of certain industries, such as brewing and milling. In this way the nutritive value and

palatability of winter rations were greatly increased, and the time required to prepare a store beast for the butcher was much reduced.

The management and feeding of cows in winter vary very much with climate and district. In the South of England, where the climate is mild, the cattle are out during the best part of the day, being brought into yards and open sheds for the night and for purposes of milking. In the North of England, on the other hand, where the weather is often inclement, dairy stock are kept entirely indoors during the best part of the winter, only being allowed out for a short time each morning to get watered. It must be remembered, however, that in those districts in which the housing system is strictly adhered to, there is all the more chance of tuberculosis being developed, owing, in many cases, to the lack of proper ventilation and sanitary precautions. Good results have been obtained in some districts by keeping cows out of doors all the year round, both day and night.

Cows need a diet somewhat relaxing to the bowels, so that in winter they require roots and meadow hay, together with small quantities of linseed or treacle, to be used along with the coarser forage. Swedes, turnips, kale, cabbage, kohl-rabi, mangels, carrots, and parsnips may all be used with safety during the winter for the production of milk. In addition to these, it will be necessary to use a mixture of concentrated foods, not exceeding 10 to 12 pounds per day, to strengthen the ration where cows are producing milk during the winter. Both sorts of cotton-cake, soya-bean cake, dried brewers' grains, bran, oats, and maize are all suitable.

Relation between Food and Yields. It is very necessary for purposes of economy that some relation should exist between the amount of artificial food given and the milk yielded, and it ought to be the duty of the cowman to see that those cows which are putting their best into the pail should receive the full quantity of cake and meal, while those which are falling off should have their concentrated food reduced.

Experience and the results of numerous tests seem to point to the fact that the food affects the quantity of the milk rather than the percentage of solids it contains; and that the quality of the milk is determined rather by the natural capacity or constitution of the cow than by the amount of food it eats. Thus, some cows yield milk naturally rich in butter fat, while others are exactly the reverse in this direction. This is a distinctly interesting point to note when we take into account the present legal standard of 3 per cent. of butter fat.

Feeding for Beef. There are two main systems of feeding for the production of beef in Great Britain: (1) Grazing cattle on first-class pasture land during summer; and (2) feeding cattle in yards or tied up in sheds during winter.

In former days bullocks, after they had worked a season or two in the plough, and cows when they had put their best into the pail, were fed off on grass during the growing season, and the beef supply was consequently of a somewhat mature character. Now, however, everything has changed. The public demand small, succulent joints with plenty of lean meat, and the farmer and grazier have had to alter their methods accordingly. Bullocks and heifers are consequently fed off at two to three years old.

On the best English grazing lands, as in Northamptonshire and Leicestershire, strong stores—unless bred on the farm—are bought in the spring markets at about three years old, and at once turned out to graze. Toward the end of the summer these beasts should be ripe and ready to go off, having increased some two hundredweight or more in live weight. In a good grass year on first-class feeding land it is even possible to put on a second lot towards autumn, and to finish these off with cake before winter comes.

The methods of feeding cattle in yards, boxes, and sheds during the winter are principally followed in the eastern parts of England and Scotland where large arable farms exist, and where it is necessary to manufacture quantities of yard manure for use on the ploughed land. In these cases turnips, swedes, mangels, straw, and hay grown on the farm form the bulky food, and purchased cake and meal are added to supplement the rations and increase their nutritive and digestive qualities. The amount of concentrated food used is, as a rule, from 4 to 10 pounds per bullock per day.

The Art of Feeding. There is more in the art of feeding than people imagine, and two men may obtain very different results with the same quantity and description of food given to similar animals. The necessity for regularity in the hours of feeding cannot be too strongly insisted on, and the judgment of the stockman in studying and tempting the animal's appetite, and seeing that everything is cleared up before the next meal, is a great factor. Any unnecessary disturbance should be avoided, and the cleaning out of the stalls should be done as far as possible when the animals have some food in their troughs to occupy their attention.

The question of the preparation of the food with a view to making it more palatable and digestible is also another consideration. No doubt pulping the roots, chaffing the fodder, mixing and leaving the mass to ferment for some hours before feeding is economical where a large number of cattle are being fed, as rough fodder can often be used for this purpose which would not be palatable by itself. It also makes the food more digestible, especially in the case of young animals. Where small quantities of cattle are being dealt with, and the labour of pulping and chopping has to be done by hand, it is doubtful whether the system pays.

Milk yields, butter and cheese making are fully dealt with in later chapters on DAIRYING.

Future of the Cattle Industry. Of the enormous capital invested in the live stock intry in the United Kingdom, no less a sum than £120,000,000 must be put aside to represent the current value of the stock of cattle. From the latest figures furnished by the Statistical Department of the Board of Agriculture, it is shown that the total stock of cattle in the United Kingdom cannot be computed at less than 11,900,000 head, showing an increase of nearly 2 million since 1876.

As regards the future of the cattle industry in the United Kingdom, it should always be the aim of British breeders to maintain the reputation they have gained by keeping to a high standard and producing the best stock possible. There is also little doubt that the present class of stock required for the home markets is a dual-purpose animal, capable of producing both milk and flesh, and this type has been successfully developed by some of the best breeders.

When we consider the enormous value of the cattle industry in this country, it is easy to understand that any slight improvement that can be made by the efforts of breeders in the milk-yielding or beef-producing powers of their stock would, taken in the aggregate, represent a large increase to the national revenues. DRYSDALE TURNER

The Laws of Atomic Heat, Valency, and the Conservation of Matter. Radium: its Properties and the Modification of Physical Theories it Causes.

THE GREAT LAWS OF CHEMISTRY

Having completed, in sufficient outline, our study of the facts of inorganic chemistry, we are now in a position to review the great laws of chemistry, some of which have already been discussed. Very early in the course, for instance, we had to refer to the Periodic Law which was a sort of curiosity a decade or two ago, but which the recent study of the atom, the discovery of the rare gases of the air, and other advances in chemistry have elevated to the very foremost rank among chemical truths.

Molecules of Gases. We have also made brief reference to certain of the laws of compounds, such, for instance, as the law of fixed proportions. In this and the course of Physics, reference has already been made to Boyle's law, which states that the volume of a gas at a uniform temperature is inversely proportional to the pressure to which it is exposed, and also to the law which most commonly goes by the name of Gay-Lussac, that the volume of a gas increases, if the pressure be constant, by one two hundred and seventy-third part of its volume at 0° C. for each rise of one degree centigrade. From these laws it has been possible to deduce another, which goes by the name of Avogadro, and which states that, given equal temperature and pressure, equal volumes of all gases contain equal numbers of molecules. This is one of the most remarkable and important laws in the whole of physics or chemistry. It constitutes the only possible way of explaining the laws of Boyle and Gay-Lussac. This law states nothing whatever about the size of the molecules of various gases—a size which is undoubtedly different in each case from all other cases, but merely asserts that gaseous molecules under equal conditions of temperature and pressure occupy the same amount of space.

The Law of Atomic Heat. To these laws one more must be added, which commonly goes by the name of two French chemists, Dulong and Petit. It may be stated in several ways, as, for instance, that the atomic weight of any element multiplied by its specific heat [see Physics] is the same for nearly all elements. This figure or *constant* is known as the atomic heat. This law implies that precisely the same amount of heat is required in order to raise through one degree of temperature equal numbers of atoms of different elements in the solid state.

This law and the law of Avogadro are in entire accord with the kinetic theory of gases, which has been fully discussed in the course on Physics.

We have frequently had to observe the fact that the elements unite with one another in very definite proportions, and we have employed such phrases as *one-handed* and *two-handed*, in order to explain, for instance, the fact that it requires, as we have said, two one-handed atoms of hydrogen to unite with one two-handed atom of oxygen, in order to form water (H_2O, or H-O-H). Chemists have introduced the word *equivalents* in order to express certain facts of *valency*. They describe as the equivalent of an element that proportion by weight which will combine with or replace one part by weight of hydrogen. The facts of water lead us to observe, for instance, that, in the case of water, at any rate, 8 is the equivalent of oxygen.

The Laws of Valency. Now, by the word valency we describe the number of atoms of hydrogen with which any element will combine, or which the element will turn out from one of the compounds of hydrogen. This is as good as to say—as the reader will see if he thinks about it—that the valency of an element can always be ascertained if we divide its atomic weight by its equivalent. For instance, in the case of water we have seen the equivalent of oxygen to be 8, while we know its atomic weight to be 16; thus, its valency in the case of water is 2, or, to use our old metaphor, it is two-handed.

Valency and the Periodic Law. Until quite recently, only a few years ago, indeed, it was scarcely possible to say any more about valency than has already been said. We could simply observe the facts and state them. It seemed absolutely impossible to explain them in any way. One curious circumstance, however, could be observed, which was that valency seemed to be hinted at in the periodic law. Taking the groups of the elements in sequence, we found that the typical members of group one were one-handed, or monovalent; those of group two were two-handed, and so on. It was not stated that this is invariably the case, but it is too nearly the case to be without significance. Furthermore, as we have already noted, the rare gases of the air were found to fit into the table of the periodic law, constituting a zero group which, if there be anything in the group arrangement of valencies, ought to have *no valency at all*. And this is precisely what was found. Despite innumerable experiments, these gases are found to be incapable of entering into combination with each other or with any other element; they are *no-handed*.

The now famous work which has been done by Sir Joseph Thomson, of Cambridge, and his fellow-workers has already gone far, however, to make valency intelligible, and especially to unravel the real significance of the remarkable manner in which the periodic law respects the

facts of valency. To this subject we must return when we have discussed, so far as may be possible the wonders of radium, radio-activity, and the new chemistry.

The Conservation of Matter. On page 170 we referred very briefly to the doctrine of the conservation of matter, which asserts that in all chemical transformations and combinations no matter is ever lost or annihilated, appearances to the contrary notwithstanding. This was regarded as by far the most important of all the great laws of chemistry—fundamentally important to the chemist, and of equal importance for philosophy. The assertion of the chemist was that, whatever process occurs to change the distribution of matter or its forms, no matter is ever lost. When we burn a candle, it would seem that something is annihilated, but it is not so. If we collect the products of combustion, remove from them the oxygen with which the constituents of the candle have combined during the process of combustion, and weigh them, we find that nothing has been lost, even when tested with the most delicate balances. We also find—and this is of precisely equal importance—that nothing has been gained. There has been apparently neither annihilation nor creation.

The reason for this apparently fundamental proposition cannot be better stated than by Herbert Spencer in "First Principles": "Could it be shown, or could it with reason be supposed, that matter, either in its aggregates or in its units, ever becomes non-existent, it would be needful either to ascertain under what conditions it becomes non-existent, or else to confess that science and philosophy are impossible. For if, instead of having to deal with fixed quantities and weights, we had to deal with quantities and weights which are apt, wholly or in part, to be annihilated, there would be introduced an incalculable element, fatal to all positive conclusions."

Men once believed that things could vanish into nothing or arise out of nothing, or thought that they believed it. It is the quantitative chemistry of the last hundred years which has shown that in all chemical processes the law of the conservation, or the indestructibility, of matter is observed. But the latest researches in physical science tend to lead back in a much modified form to the original belief. It appears that during any chemical change matter actually disappears with microscopic slowness, accompanied by manifestations of energy.

A New Statement Necessary. So far, therefore, as all ordinary chemical processes are concerned, the law of the conservation of matter holds true today. This law it was that led Clerk-Maxwell to coin his celebrated phrase describing the atoms of matter as the foundation-stones of the physical universe, which have lasted since the Creation, unbroken and unworn. No power in the universe could destroy an atom. If all the other atoms in the universe were ranged against it, it would survive their attacks. But nowadays we are all aware that Clerk-Maxwell's conception of the atom is obsolete. Of this there will be no remaining doubt when we have proceeded to the discussion of radio-activity. Atoms are not like foundation stones; they consist of systems of almost infinitely smaller units, known as corpuscles or negative electrons. These systems vary in stability, though those with which we are familiar are probably the most stable that have survived, while less stable atomic systems have disappeared, in accordance with the law of the survival of the fittest, which is now believed to obtain among atoms as among organisms. If we are to adhere strictly, then, to the law of the conservation of matter as a fundamental dogma of chemistry and of philosophy, we must let the atom go and must turn to consider the electron or corpuscle.

Conservation of Energy. Now, the truth appears to be, as was, indeed, long ago discerned by the genius of Spencer, that the law of the conservation of matter must be regarded as merely a convenient aspect of a much greater law—the law of the *conservation of energy*. The belief in the indestructibility, or conservation, of atoms has had to go, since radium demonstrates to our actual vision the destructibility and impermanence of atoms. Apparently no success can be hoped for the attempt to transfer our dogma to the electron. We are very far indeed from having any proof, or, indeed, from having any reason to believe, that electrons are permanent and indestructible. On the contrary, we are compelled to look upon them as essentially transient and evolving manifestations of energy. While the great revelations of the last twenty years have greatly affected our views on the doctrine of the conservation of matter, they have equally affected the doctrine of the conservation of energy. To some aspects of this question we must return in a later section.

Radium. Everyone with a guinea to spare may become the possessor of a tiny speck of the most expensive, rare, and wonderful of all known substances. At the present rate in the rise of the value of radium, however, the makers of the remarkable toy called the *spinthariscope*, which was invented by Sir William Crookes, will soon have to raise its price. This spinthariscope is a little brass tube about an inch and a half long, which is closed at one end and has a couple of magnifying lenses at the other. On the inner surface of the blind end there is a small piece of paper which has been coated with minute crystals of zinc sulphide.

Just in front of this piece of paper there stands out a metal pointer like the hand of a watch. The end of this pointer has been dipped in a solution of a salt of radium. If, now, one takes the spinthariscope into a dark room and holds it close to the eye, one sees a shower of points of light that seem to radiate from a centre and that come from the surface of the zinc sulphide paper. This shower of sparks never ceases, night or day, year in and year out. The present writer mislaid his spinthariscope, and when he

found it again after some months and saw this shower of sparks still occurring, and realised that it had never ceased throughout the intervening period, the most amazing of all the features of radium was at last brought home to him. After nine years he revises these lines, and his spinthariscope is still showering burst atoms as ever.

Estimated Duration of the Energy of Radium. Various calculations have been made as to the length of time during which the scanty deposit of a radium salt upon the pointer of a spinthariscope will continue to evolve the energy of which the shower of sparks is the manifestation. The least estimate runs into thousands of years.

The ceaseless flashes of light are believed to be due to the cracking and splintering of the crystals of zinc sulphide by means of something which flies out from the radium and strikes them. Thus, it is probable that the paper may require to be renewed after some time; but that is merely because it will cease to indicate what does not cease—the continual evolution of energy by the radium within the spinthariscope.

Sometimes the owner of a spinthariscope is annoyed to find that the shower of sparks is very inconspicuous. If the toy be slightly warmed, the shower will soon reappear. Whatever the cause of this fact be, it has certainly nothing whatever to do with the behaviour of the radium itself. For radium continues to evolve energy in liquid air or hydrogen at a temperature more than 200 degrees below zero just as well as it does at ordinary temperatures. Indeed, its behaviour seems to be unaffected by anything that we can do to it. Since these words were first published, students all over the world have been devoting their lives to the discovery of some means of controlling the decomposition of the radium atom; but all have wholly failed so far.

The New Alchemy. Now, the sight which the spinthariscope affords is really the vindication of the much-abused alchemists, who sought to turn the baser metals into gold. Later generations laughed at them and said: "Oh, no, you cannot transmute one element into another, for each element has its own kind of atom; and the atoms are the unalterable foundation-stones of the universe. They cannot be changed into one another, and so you cannot change lead into gold. Your philosopher's stone is a myth." But this supposed impossible thing is precisely what is happening in the spinthariscope. Let us consider the facts.

Radium is certainly an element—as much an element as gold or lead or any other; and, of course, it has a characteristic atomic weight of its own. This was variously estimated at first, Madame Curie, the discoverer of radium, estimating it to be 225; while other observers, using other methods, estimated the figure to be 256. This last would constitute radium the heaviest of all known substances. Madame Curie, however, has been proved to be right, and radium is recognised as the third heaviest of known substances, the heaviest being uranium, with an atomic weight of 240, and the next thorium, with an atomic weight of 232. The fact that the atomic weight of uranium is greater than that of radium is extremely important, as we shall see when we come to discuss the evolution of radium.

The Emanation of Radium. Now, if some of this element be confined in a tube, we find, after a time, that there appears in the tube a minute quantity of a gas or *emanation* which was not there before. This is not gaseous radium, for when it is examined with the spectroscope it shows a spectrum quite different from that of radium; in fact, its spectrum is quite different from that of any known substance. But it was discovered by Sir William Ramsay that if the spectrum of this mysterious emanation be examined again after an interval of about four weeks, it is found to have changed into a familiar spectrum which is instantly recognisable as that of the rare element known as *helium*. The astonishing fact, then, is that the element radium decomposes itself and produces another element, helium. Now, the atomic weight of helium exactly corresponds to the weight of the tiny particles which are now known to be shot out from radium, constituting what are called the *alpha* rays. These particles, flung out from the radium upon the pointer of the spinthariscope at an incredible speed of tens of thousands of miles per second, bombard the zinc sulphide paper and so produce the shower of sparks to which we have referred.

Radium and Universal Evolution. In the history of the science of radio-activity, this great discovery of Sir William Ramsay's takes a prior place, since it proves once and for all that the doctrine of universal evolution is applicable to atoms. Herbert Spencer's original definition of evolution, framed more than forty years before the discovery of radium, is as applicable to the facts discovered so lately as if it had been framed in order to describe them. Thus the most important fact about radium for the philosopher, the physicist, and the chemist alike, is that it proves the truth of atomic evolution. Not even an atom is immune from the universal law of unceasing change, and thus every spinthariscope is a lasting refutation of that memorable phrase of Clerk-Maxwell's to which we have so frequently referred. Furthermore, radium has proven that Sir John Herschel and Clerk-Maxwell were wrong when they declared that the atom bears upon itself the "stamp of the manufactured article." Atoms are not manufactured, but have evolved and are evolving at the present moment.

The Evolution of Radium. Of all the elements, the last that radium suggests to the mind is lead, unless, indeed, the suggestion were by contrast. Lead has long stood as the symbol for all that is mean and worthless and dull and unremarkable; while we know radium to be the most brilliant, the most valuable, and incomparably the most remarkable of all the elements. Lead stands for something worse

than mediocrity, radium stands for uniqueness and genius. Yet in recent years it has actually been discovered that lead—almost certainly—has its place in that evolutionary chain of which radium is the most remarkable link.

But before we ask what becomes of the atom of radium, let us inquire into its own origin. We know that there is extremely little radium in the world, and we find that what radium there is, is constantly being decomposed into simpler elements. Indeed, we can barely understand the facts unless we assume that, while radium is itself being decomposed, it is, on the other hand, being produced in some way or other the amount of radium actually existent at any one time being determined by the comparative rates of these two processes. We now, indeed, have every reason to believe that radium itself is the child of uranium—wherein lies the importance of the fact, upon which we have insisted, that the atomic weight of uranium is greater than that of radium. These two elements are associated with one another wherever they are found; and not only so, they are associated in a constant ratio. This ratio is determined entirely by the relative life periods of the uranium and the radium atoms.

Radium and Lead. As we have already seen, the so-called *alpha* rays of radium are now known to consist of material particles, each of which must be regarded as an atom of helium in a state of great excitement and activity. Now it is obvious that the radium atom cannot continue to lose an indefinite number of these immature atoms of helium without itself undergoing certain changes. In fact, the radium atom is changed. When it has lost one atom of helium it is no longer a radium atom, but the atom of another element.

It is now believed that each radium atom is capable of losing in succession five atoms of helium. At each stage it is a different and definite product and must receive a different and definite name. (These names have not yet been quite agreed upon, but the reader may have heard of actinium and polonium, the latter having been named by Madame Curie after her native country. It is now seen that these names must apply to various stages in the transmutation of the atom of radium.) And now we come upon the extraordinary conclusion, apparently beyond all dispute, that when five such helium atoms have left what was originally an atom of radium, the atom left behind is none other than an atom of lead.

Origin of Radium. It is obviously not correct, however, to use the phrase, "originally an atom of radium," for we know that the radium atom, large, heavy, and complicated though it be, is yet none other than a decomposition product of a heavier, larger, and still more complicated atom—that of uranium. What are we to say of this? Is the uranium atom also only a temporary product of an element consisting of atoms yet heavier and more complex than its own? This, indeed, seems highly probable, though no such element is known. But it is not easy to see where we are to stop in the speculations which these new discoveries have suggested. Though uranium has the heaviest atom we know, there is no conceivable reason why it should be the heaviest atom possible. Indeed, it has been suggested that we must go back in thought by successive stages to a period when the whole universe was one kind of atom.

Where does Atomic Evolution stop? Yet if we have difficulties in this direction, we have difficulties no less in the other direction. The atom of lead is extremely heavy and complex. Why should it be the last stage in the process which "began" with uranium? No one, indeed, now thinks that it is the last stage, and by some it is thought that the element silver, which is so constantly found in association with lead, may represent the next most striking stage in this particular sequence of atomic evolution. But in this direction also, where does the process stop? Are we to suppose that the universe began as one huge atom, and that its last stage will be represented by the breaking down of all atoms into what we now believe to be the common constituent of them all, the electron of negative electricity?

Helium. However these things may be, we must at any rate study, so far as is possible, the remarkable element helium, which is so positively known to be a product of the decomposition of radium. When the spectrum of the protuberances of the sun was first studied, it was found to indicate the existence of an element with which chemists had no acquaintance. But it was subsequently discovered by Sir William Ramsay that this same element is present in a rare Norwegian mineral which has the name of cleveite; the element is now known as helium (from Greek *helios*, the sun). Thirty years elapsed between the discovery of helium in the sun by the late Sir Edward Frankland and Sir Norman Lockyer in 1868 and Sir William Ramsay's demonstration of the existence of this element upon the earth. This is the one substance which Sir James Dewar was unable to liquefy. He writes: "It has been expanded from a pressure of 80 to 100 atmospheres at the temperature of solid hydrogen without the least indication of liquefaction being perceived, although in this connection it must be remembered that its exceedingly low refractivity would render small drops of the liquid forming in the gas near its critical point very difficult to see.

"It may, however, be said without much doubt that helium has been cooled to 9 or 10 degrees absolute (264 or 263 degrees below zero centigrade) without sign of liquefaction, and the inference is that its critical point is below 9 degrees absolute. This means that its boiling point is about 5 degrees absolute, or one-fourth that of liquid hydrogen." But, a year or two later, Professor Kamerlingh Onnes, of Leyden, succeeded, and now even helium has been liquefied, with the attainment of the temperature, 5 degrees absolute, correctly predicted by Dewar.

C. W. SALEEBY

BARBAROSSA IN IMPERIAL SPLENDOUR

THE ELECTION OF FREDERIC BARBAROSSA AS GERMAN KING IN 1152

CONFERRING KNIGHTHOOD ON THE SONS OF BARBAROSSA AT MAINZ IN 1184

The Age-long Rivalry of Guelf and Ghibelline. French Mastery in France. The Growth of Liberty in England.

THE CROSIER AGAINST THE SWORD

THOUGH the contest about investitures between the ecclesiastical and temporal powers was formally closed, abundant materials for strife between emperor and pope still remained, and, as the eleven hundreds rolled on, a new element—Republicanism—made its appearance in Italy. When men first awoke from the torpor of the dark centuries, remembrances, dim, but majestic, of the mighty republics of old, of Rome, and of all the bright train of her subject sisters, the municipalities of Italy, began to stir in their souls; and now, too, the democratic side of Christianity began to display itself, especially to some of the inmates of the cloister.

Such a man was Arnold of Brescia (1136-1155), who preached republicanism and the abrogation of the temporal power of the priesthood in language which now sounds strangely modern; and he actually succeeded for a time in setting up a republic in Rome. All over Italy, but especially in the valley of the Po, the cities began to withdraw themselves from the feudal organisation of the empire, or to claim that the feudal rights which remained should be vested in their own elected magistrates, to whom they generally gave the proud old name of consuls.

This movement inevitably brought them into collision with the man in whom all feudal rights and privileges were summed up, the man who wore the imperial crown, and that man in the middle of the eleven hundreds was one of all others least likely to forgo a tittle of his rights—Frederic Barbarossa of Hohenstaufen, Duke of Swabia and Emperor of Rome. This great emperor, one of the greatest in the long line of mediæval Cæsars, had some qualities in common with our own Edward Plantagenet. Like him, proud, brave, and strong; like him, generally a man of his word, and with a deep conviction of the duties laid upon him by his high office, but, unfortunately, with a tendency to ride his steed, the people under his rule, with too sharp a bit, thus his very virtues were in danger of becoming crimes. His determination to put an end to anarchy and to assert the just claims of the empire degenerated more than once into tyranny and oppressive cruelty.

The chief quarrel of the emperor was with Milan, that stately city which had often been the residence of the old, the genuine Augusti. Frederic's chief ally in Italy was the Lombard city of Pavia. Milan, at first rather feebly supported by her sister-cities, drew strength from the support of the Popes—first, that of Hadrian IV., the only Englishman who has ever worn the triple crown; and then that of Alexander III. (1159-1179), who, in his turn, leant upon the somewhat uncertain help of his Norman vassal, William, king of Sicily. After seven years of war, in which the combatants had been growing ever more exasperated against one another, the emperor, having starved Milan into submission, received her unconditional surrender in 1162. He ordered the city to be levelled with the ground, and sent the citizens forth to wander as beggars through the cities of Italy, all save a remnant, who were allowed to live in four villages planted near their old home.

But here the emperor had overshot his mark. The piteous tale told by the banished Milanese roused the sympathies even of their former foes. In 1167 the Lombard League was formed, a confederation which included nearly all the cities of Lombardy; Milan was rebuilt and received again her old inhabitants; the strong city of Alessandria was built and named after the Pope, patron of the league. Frederic's armies were more than once all but annihilated by disease, engendered by summer heats and ill-drained plains; and at last, in 1176, the twenty years' struggle was ended by the battle of Legnano, in which the Italians won a complete victory, and Frederic, after witnessing the terrible slaughter of his men, with difficulty escaped from the field.

Convinced that it was a hopeless task to overcome the independent spirit of the Lombard republics, Barbarossa now thankfully accepted the mediation of Alexander III.—against whom he had been raising up one anti-pope after another for the preceding

ten years—met him at Venice, and, humbly kneeling before him, obtained the removal of the ban of excommunication for himself and his adherents. It was on this occasion that, according to a picturesque but untrustworthy legend, the Pope set his foot on the neck of the prostrate emperor, saying, with exultation, "Thou shalt tread upon the lion and adder, the young lion and the dragon shalt thou trample under foot."

The emperor then returned into Germany, but in 1183 recrossed the Alps, and meeting the delegates of the Lombard cities at the fair city of Constance, concluded with them a treaty which was the basis of the public law of Italy for centuries. The regalia, or rights of sovereignty, claimed by the emperors, were greatly limited, the right of the cities to levy taxes and to elect their own chief magistrate was recognised; the Lombard League itself was solemnly authorised by the emperor. From this time onwards the dependence of the cities of Italy upon the empire was ever tending to become more precarious and shadowy. Italy and Germany began more and more to trace out their peculiar and separate orbits.

The Papal Guelfs and Imperial Ghibelines. During these contests two party names, which were destined to shed a lurid light over Italian politics for many centuries, first came into being. These were the names of Guelf and Ghibeline. The Dukes of Bavaria and Saxony—from whom, through the Electors of Brunswick, our own royal family is descended—bore the name of Guelf; and these, partly from mere antagonism to the other family, were almost invariably found siding with the pope against the emperor. On the other hand were the two families of Franconia and Swabia, which between them ruled the whole south-western quarter of Germany, which were connected by close family ties, which ruled the empire for two centuries—the Henries belonging for the most part to the Franconian, and the Frederics to the Swabian line; and these were found with equal constancy on the side opposed to the popes, whom the Church finally recognised, and against whom they raised up innumerable anti-popes.

Religious Democracy versus Knightly Loyalty. The Swabian emperors, who are now generally known in history by a surname derived from their castle of Hohenstaufen, seem to have been better known among their contemporaries by the name of Weiblingen, which their Italian subjects, intolerant of the "W," converted into Ghibeline. These two party labels were taken over from German into Italian politics, and had a far longer and more vigorous life in Italy than in their native land. Even so, we may remark in passing, the words "Whig" and "Tory" were imported into English party warfare from Scotland and Ireland respectively. Of course, in the fierce cross-currents of Italian urban strife they often drifted far from their moorings; but, speaking generally, we may say that the Guelf swore by the pope, and the Ghibeline by the emperor; the Guelf leaned towards republicanism, the Ghibeline towards feudalism; religious democracy was the ideal of the former, the ideal of the latter was knightly loyalty.

The Death of Barbarossa. The last and most brilliant of the Hohenstaufen emperors was Frederic II. of Sicily. His grandfather, Frederic Barbarossa, having in his old age embarked on the Third Crusade, was marching through Asia Minor, and had already reached its south-eastern corner when, plunging in on a day of burning heat into the little Cicilian stream Calycadnus, he caught a sudden chill, resulting in a fever or a stroke of paralysis, by which he was almost immediately carried off. Though he was buried in that far-off Asiatic land, the imagination of the Germans pictured the glorious emperor still living in an enchanted sleep in a cave of the mountains near Salzburg, from which he should one day burst forth in the time of his country's darkest need to champion her cause. Yet Louis XIV. and Napoleon came, and still Barbarossa slumbered.

How Malaria was a Papal Defence. The son and successor of Barbarossa, Henry VI., emperor from 1190 till 1197, was a man of base and ignoble nature, whose most memorable action was the arrest and imprisonment of our Richard Cœur-de-Lion on his return from the Holy Land. He made, however, a most successful matrimonial venture when he married Constantia, who was ultimately the heiress of the Norman kings of Sicily. He thus acquired dominion over the whole south of Italy, and made the House of Hohenstaufen more terrible and more hateful than ever to the papacy, which saw itself girt in on every side, north, east, and south, by this inexorable foe. But Henry VI. died in the prime of life, a victim probably to that fatal climate of Italy, which was the keenest of all Guelfic partisans.

The Pope who Reared an Emperor. His wife Constantia, whom he had sorely wounded by many cruelties towards her kindred and her people, died a year after him; but before dying left her son, a little boy of four years old, under the guardianship of the pope. This orphan child was the future Emperor Frederic II. Guardian and ward were each to play a great part on the stage of history, the first in the early, and the second in the central years of the century; but two more diverse characters could hardly be imagined. The pope who received Constantia's dying charge was none other than the famous Innocent III., greatest of all the popes but Hildebrand, the man who organised the Fourth Crusade and ruthlessly rooted up the heresy of the Albigenses; the man who brought John of England to his feet and made the English kings his vassals; the man, too, who harnessed the enthusiasm of St. Francis and St. Dominic to the chariot of the Church. A Roman noble, calm, strong, self-possessed, he showed that the imperial race had not quite forgotten the secret of "ruling the nations," that it could still "spare the fallen and war down the proud."

THE DEFEAT OF FREDERIC BARBAROSSA BY THE LOMBARD LEAGUE AT LEGNANO

THE CAPTURE OF MANFRED'S FAMILY AFTER THE BATTLE OF BENEVENTO

The Last Brilliant Swabian Emperor. The child Frederic, son of a German father and a Norman-Italian mother, grew up to the age of seventeen in his mother's native Sicily, amid many perils, from which he was on the whole faithfully shielded by a pope, the predestined enemy of his race. When his character fully declared itself, when his position as emperor of Rome and king of Sicily was established beyond possibility of question, he was indeed, as he was often called, "stupor mundi," an object of bewildered wonder to the world. The emperors who followed Charlemagne, especially the emperors of the three previous centuries, had been for the most part brave, thick-headed German soldiers, silently despised as "barbarians" by their Italian vassals. But now, behold! the imperial diadem was worn by a man more Italian than the Italians, a man who spoke six languages—Latin, Italian, German, French, Greek, Arabic—and who wrote poetry in one of them—the young "volgare" dialect of Italy. Here was a troubadour upon the throne, yet also a skilled and resolute soldier; a free-thinker, too, in that most orthodox age; a man who consorted with Saracens, and who dared to say: "If the Almighty had ever seen my beautiful Sicily, He would never have given that arid Palestine as a possession to His chosen people." And yet this free-thinking emperor could also be, when it served his purpose, a cruel persecutor of heretics. There is much in the character of Frederic II. to move our just condemnation. We are always fascinated by his brilliant, many-sided personality, but we never quite love him.

Frederic of Sicily and the Church. By the help of the papacy the young heir of the Hohenstaufen not only preserved his Norman-Sicilian kingdom, but in 1215 won the imperial crown from a competitor, Otto of Bavaria (1198–1215), who, though sprung from a Guelfic family, had incurred the hostility of Innocent III by his too strenuous advocacy of the rights of the Cæsar. Scarcely, however, was Frederic seated on his throne when dissensions arose between him and his foster-mother the Church. The ostensible ground for these dissensions—a real cause of quarrel between Pope and a Hohenstaufen could never be lacking—was the fact that, on the day after his election, Frederic, perhaps in a moment of enthusiasm, had assumed the Cross and taken a vow to deliver Jerusalem from the hands of the infidels. This obligation was solemnly urged upon him by successive popes, by the mild and good-tempered Honorius III. (1216–1227), and by the irascible old pontiff Gregory IX. (1227–1241), who, with octogenarian bitterness, launched the thunders of the Church at his devoted head.

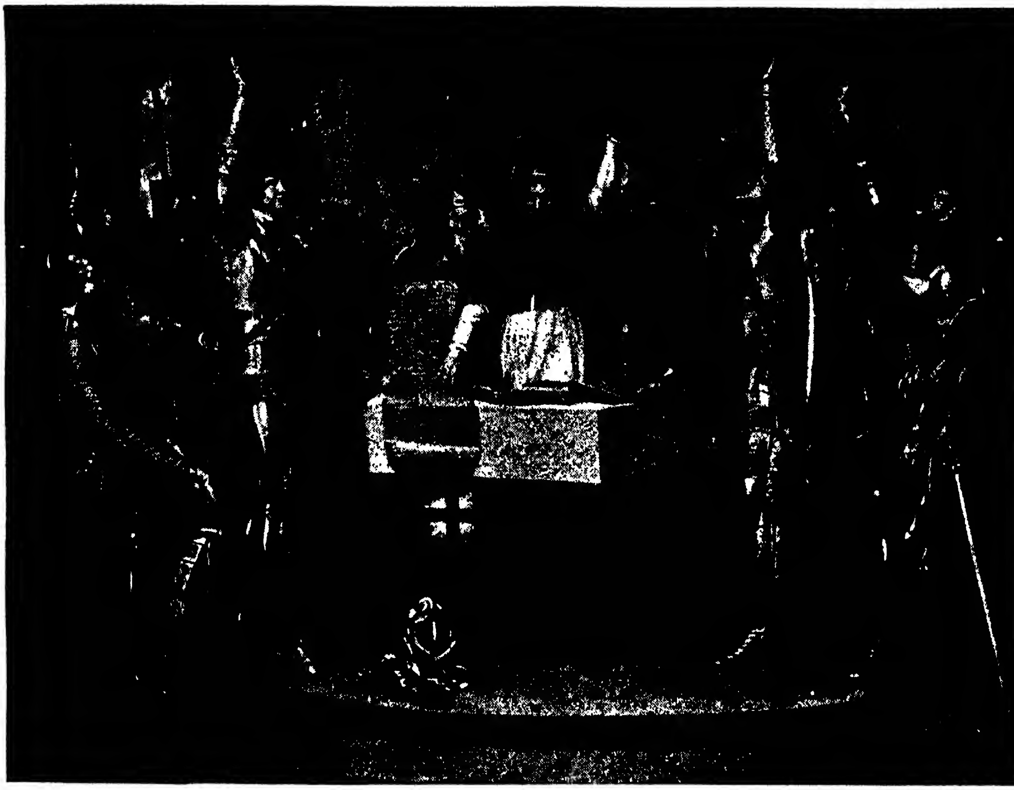
A Strange Excommunication. It must be admitted that Frederic was exasperating in his behaviour with reference to this Crusade. He was always about to start in two years' time, "if only you will leave me unexcommunicated so long," and always found something to do in crushing Norman barons or Guelfic citizens, which, when the end of the two years came, made it impossible to leave Italy just then. When at last, in September, 1227, he did set sail from Brindisi, a fatal sickness, the result no doubt of the neglect of sanitary precautions, broke out in his army, carrying off some of the chiefs of the expedition, and attacking the emperor himself, whereupon he, not unnaturally, doffed his armour and returned to his palace in Sicily. The sickness seems to have been genuine, but the pope chose to consider it feigned, and hurled a furious bull of excommunication at the offender.

The Recovery of Jerusalem. There was evidently more of spite than of statesmanship in this proceeding, for when in the following year, 1228, Frederic in good earnest started for the Sixth Crusade, the excommunication remained unrepealed. Every place at which he might land was laid under an interdict, and this interdict was extended even to Jerusalem itself, which Frederic, it must be confessed, by diplomacy rather than by arms, had recovered for Christendom. We have said that the whole conduct of the pope at this crisis seems to have been dictated by passion rather than by policy. If the Crusade were to have any chance of success, it was essential that the Crusaders should be of one heart and one mind, and should feel that they had with them the blessing of the Church.

War to the Death with the Papacy. Moreover, Frederic, who had now taken for his second wife Yolande of Brienne, and in right of that marriage had assumed the title of King of Jerusalem, had reasons of his own for making the Crusade a real success, and should surely, from the narrowest point of view of the papal interests, have been encouraged to spend as much of his strength as possible in the East, instead of returning to fight the cause of Ghibelinism in Italy. That, however, was what he actually did; and the remaining twenty-one years of his life (1229-1250) were one long and deadly duel with the popes, first with octogenarian Gregory and then with a more subtle, but less reputable foe, Innocent IV. This pope, in his humbler capacity as Cardinal Fieschi, had been classed among the partisans of the empire, but when Frederic was congratulated on his elevation he answered with too true a presentiment: "I have lost a friend and not gained an ally. No Pope can ever be a Ghibeline."

How the Crosier Beat the Sword. After the death of Frederic, in 1250, and the short reign of his son, the Emperor Conrad IV., the young and brilliant Manfred was proclaimed king of Sicily. An illegitimate son of Frederic II., he inherited many of his father's attractive qualities and therewith the undying enmity of the papacy. Like Frederic, he leaned much on the support of a military colony of Saracens established in the fortress of Lucera, whose vast circuit of walls, resembling a greatly magnified Caernarvon Castle, may still be seen on a hill of Apulia. Under Manfred's able guidance the Ghibeline party in Italy was fast rising into domination, when the pope, Urban IV.,

THE BEGINNING OF OUR ENGLISH FREEDOM



THE BARONS OF ENGLAND MAKE OATH TO COMPEL KING JOHN TO GRANT THE CHARTER

THE HISTORIC SCENE AT RUNNYMEDE, WHERE KING JOHN YIELDED TO THE DEMAND OF THE BARONS

who happened to be a Frenchman, took the fateful step of inviting one of his countrymen. Charles of Anjou. brother of St. Louis, to enter Italy as the champion of the Guelfic cause and wrest the crown of Sicily from Manfred. He came; he conquered his opponent on the desperately fought field of Benevento on February 26th, 1266. The body of the excommunicated "Sultan of Lucera," as the victor derisively called him, was buried in unconsecrated ground.

The Political Effect of the Rapier. The long duel between the Popes and the Hohenstaufen was ended; the old priest's crosier had beaten the young knight's sword; or, more literally, the victory seems to have been won by the rapier over the sabre. The French had recently introduced the former weapon, and while the Italian soldier was lifting his great broadsword for a downstroke, the agile Frenchman thrust in his rapier's point and let out the life of his antagonist. Here, too, virtually ended the battle between the papacy and the empire. Each will have other foes in the portion of history which lies next before us; but they will not be so directly pitted against one another as they have been for these two centuries.

The Relations Between Normandy and France. We have heard little of France or England from the time when the Norman Duke William seized the English crown, and provided his descendants with a kingdom which was independent of the French prince to whom in the character of Duke of Normandy he owed allegiance. Now we remark that, until the end of the eleventh century, the French king had been to all intents and purposes merely one nobleman among many, who recognised merely a formal sovereignty on his part, while there were, perhaps, half a dozen any one of whom could bring into the field an army as large as the king could muster unless his great feudatories chose to aid him. In fact, though the Duke of Normandy did homage to the king of France, he was perhaps rather the more powerful of the two. But it was about this time that the French kings of the House of Capet began to encroach upon the power of their feudatories, to play off one against the other, to appropriate to themselves every scrap of territory to which a legal claim could be pretended.

STATUE OF RICHARD I. OUTSIDE THE HOUSES OF PARLIAMENT

The Plantagenet Heir to Half of France. Nevertheless, by the middle of the twelfth century or within a very few years afterwards, one great feudatory had acquired, partly by inheritance and partly by marriage, counties and dukedoms which extended over a full half of France. On the death of William the Conqueror, Normandy was temporarily separated from the new acquisition of England, one son taking the dukedom and another the kingdom. At the very beginning of the twelfth century, however, William's third son, Henry I., having seized the English crown, ejected his elder brother Robert from the Norman dukedom, and joined Normandy again to his own dominion. Both in his kingdom and in his dukedom Henry I. was succeeded by his nephew, Stephen of Boulogne, whose elder brother, Theobald of Blois, declined to assert his own claim. But Henry had a daughter, the widow of the German emperor Henry V., whom he married to another great French feudatory, Geoffrey of Anjou. The Empress Maud claimed the succession for herself and for her son Henry. After civil war and anarchy had for some time raged in England, Stephen was allowed to retain possession of the crown and the dukedom till his death. In both he was then succeeded by the son of the Empress, Henry II., the first Plantagenet King of England, Count of Anjou as his father's heir, who had also married Eleanor, the heiress of Aquitaine, which meant the whole south-western quarter of France. The dukedom of Normandy carried with it the overlordship of Brittany, so that the whole western half of France, and something over, formed part of the Angevin or Plantagenet dominion, as well as the kingdom of England, for which Henry owed no allegiance to the French king.

The Rise of Public Spirit in England. The name of Henry is great in the annals of England. Under him it may be said that the fusion between Normans and English was completed, though there was still a French-speaking Norman aristocracy and still a class of purely English serfs. The great mass of what may be called the minor baronage or gentry had English as well as Norman blood in their

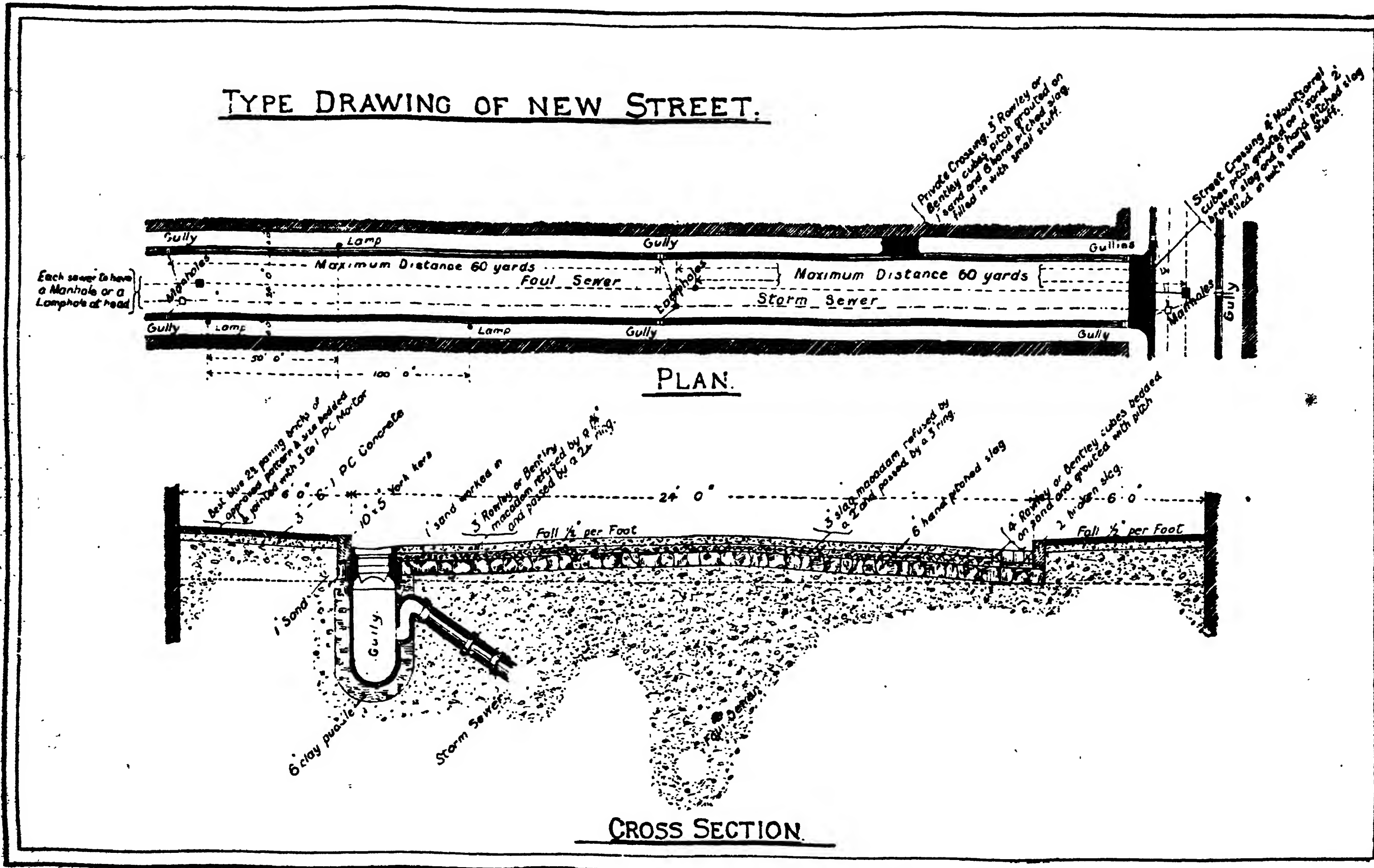
veins in various proportions, and had come to regard themselves as English. Moreover, after the wild anarchy of Stephen's reign, the great nobles as well as the minor barons had learnt to desire the reign of law and order. A new sense of public spirit had been awakened. Hence, when there were outbreaks among the feudatories in defiance of the crown, they were crushed with unexpected ease, and Englishmen at large became accustomed to range themselves on the side of law against any encroachments, whether on the part of the crown or of powerful nobles. This progress of public spirit was made clear by the steadiness of the country during the prolonged absence of Richard I., and still more in the reign of King John, when the barons compelled him to sign the Charter which was virtually a pronouncement that the king was to obey the law as well as everyone else.

From the European point of view, however, Henry of Anjou was a potentate of the first class, entirely irrespective of the fact that he was also Henry of England. But just before Henry's death the French crown passed to the extremely astute and entirely unscrupulous Philip Augustus. Philip failed in his efforts to break the power of Richard I., but with John he was entirely successful, so much so that on various pretexts of feudal law, backed by arms, he deprived the King of England of all his possessions in France, except the seaboard of Aquitaine, and only just failed to procure the deposition of John in England in favour of his own son Louis.

The Supremacy of the French Kings in France. The French crown, too, was fortunate in Philip's successors, both men of high character; while the second, Louis IX., is one of the most universally and most deservedly admired figures in the whole of the Middle Ages. The forfeiture from King John vastly increased the royal estates; further great additions were made during the ensuing century partly by the lapses of fiefs without heirs, partly by the marriage of princes of the blood to heiresses of great estates. By the end of the thirteenth century the king and his immediate kinsmen held greater estates than all the rest of the nobility put together; and Philip the Handsome was turning greedy eyes upon what was still left to the King of England in Aquitaine.

The Emergence of Popular Rights in England. In England, on the other hand, it became increasingly clear during the half century which followed the death of King John first that the majority of the barons great and small wished to be loyal to the crown, and were extremely reluctant to challenge it in arms; but, on the other hand, that they were ready in the last resort to appeal to arms, and that if they did so in the name of the law, to insist upon just administration in accordance with the law, the crown would be unable to crush them. But Simon de Montfort showed, too, that the strength of the baronage lay not in their action as an aristocracy, but in the maintenance of popular as well as baronial rights, and in the support of the whole body of public opinion. That lesson was learnt by the prince who himself overthrew Earl Simon in the battle of Evesham. He as Edward I. made the crown itself the champion of the law, and permanently established the popular representation in the National Council (now called Parliament) which counterbalanced the tendency of the greater barons towards the substitution of a narrow oligarchy of birth for the supremacy of the crown. Edward himself was probably unconscious that by so doing he was paving the way for making not the crown nor the greater barons, but the Commons, the supreme power in the State.

THE SUBMISSION OF KING JOHN OF ENGLAND TO THE REPRESENTATIVE OF THE POPE



14. A SURVEYOR'S DRAWING FOR THE LAYING OUT OF A NEW STREET

Plans and Estimates. Dedication as Public Highways. Setting out Footpaths. Paving Materials. Costs of Construction and Maintenance.

NEW STREETS & FOOTPATHS

A *street* defined by the Public Health Act, 1875, and the Private Street Works Act, 1892, is a highway, bridge (not being a county bridge), road, lane, footway, square, court, alley, or passage, whether a thoroughfare or not.

Highways under the Highway Act, 1835, mean all roads, carriageways, cartways, horseways, bridleways, footways, causeways, churchways, and pavements.

Requirements of Local Authorities. Section 150 of the Public Health Act, 1875, enacts that where any street within any urban district (not being a highway repairable by the inhabitants at large), or the carriageway, footway, or any other part of such street is not sewered, levelled, paved, metalled, flagged, channelled, and made good, or is not lighted to the satisfaction of the urban authority, such authority may, by notice addressed to the respective owners or occupiers of the premises fronting, adjoining, or abutting on such parts thereof as may require to be sewered, levelled, paved, metalled, flagged, or channelled, or be lighted, require them to sewer, level, pave, metal, flag, channel, or make good, or to provide such proper means for lighting the same within a time to be specified in such notice.

If such notice be not complied with, the urban authority may, if they think fit, execute the works mentioned or referred to therein, and may recover in a summary manner the expenses incurred by them in so doing from the owners in default, according to the frontage of their respective premises, and in such proportion as is settled by the engineer of the urban authority.

Powers of Urban Authorities. An urban authority may adopt the Private Street Works Act, 1892, in place of sections 150, 151, and 152, of the Act of 1875. Under this Act, questions between the owners and the authority as to whether the street is one which can be made up at the owner's expense, as to informality in the notices, etc., as to the sufficiency or reasonableness of the works, and as to the apportionment of the expenses, are to be determined before the works are actually executed.

This more recent enactment is that under which most of the private streets are now made by their respective owners.

The period usually allowed by the Local Government Board for the repayment of Loans for Private Streets Works is from four to six years.

Plans, Sections, and Estimates. Before a local authority gives the owners notice to make up a street, their engineer must prepare plans and sections, which should be on a scale of not less than 1 in. for 88 ft. for a horizontal plan, and on a scale of not less than 1 in. for 10 ft. for a vertical section, such plans, with the estimate, being deposited in the council's offices, and open at all reasonable hours while the notices run, for the inspection of all persons interested therein.

Before the preparation of such plans and sections, it will be necessary for the engineer to make an accurate survey of the street or streets to be made up.

Each frontage is measured and entered in a book, these dimensions acting as a check to the plotting of the various points taken from the offsets off the chain line.

Plans should be neatly and clearly drawn; if the plans are on loose sheets, there should be a title and scale on each sheet, and the date, with the name of the engineer clearly written in the right-hand corner.

Details, such as manholes, type of gully, paving, etc., should be drawn to a large scale, with figured dimensions.

The Preliminary Survey. The plans and detailed section can be prepared only after an accurate survey of the streets. The section should show a horizontal "datum line," and lines showing the "formation level," and "finished surface" of the proposed works. Figures should also be given on the datum line for the horizontal distances, corresponding exactly with those on the plan, and the heights of the surface of the ground above datum require to be marked at intervals, as well as the depths of the sewers with their cross-sectional dimensions and gradients distinctly marked upon them.

A detailed estimate, showing particulars of the probable cost of the whole works, including a commission of 5 per cent. (which is allowed under Sec. 9) in respect of surveys, superintendence, and notices, should be prepared and must include provision for sewering, levelling, paving, metalling, channelling, kerbing, making good, and providing proper means of lighting.

Each street to be made up must be kept entirely distinct. Fig. 14 illustrates the laying out and making up of a new street; Fig. 15 is the plan of a private street showing apportionments.

Apportioning Cost Among Owners. Under the Public Health Act, 1875, the principle adopted in making the apportionment is based on frontage only, but the Private Streets Works Act, 1892, gives the local authority power to decide whether the apportionment is to be made according to the frontage only or to take into account the degree of benefit derived by any premises having access from the street, and the amount of work already done by any of the owners. Therefore, before the engineer proceeds

to prepare the provisional apportionment, he must be clear on these points.

The provisional apportionment should show the amounts charged on the respective premises, the names of the respective owners, or reputed owners, also whether the apportionment is made according to the frontage of the respective premises or not, the measurements of the frontages, and the other considerations (if any) on which the apportionment is based.

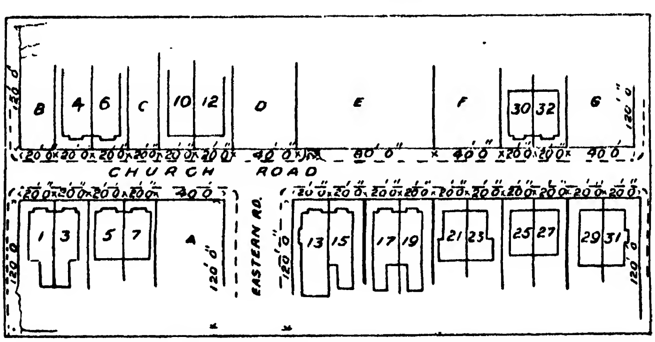
This work should be accurately done, as it must be remembered that the exact measurement of a frontage is usually known to the individual who owns the premises.

Street Intersections. As regards the intersections of streets, the usual practice is to include the cost of the intersections of streets in the amount to be apportioned over the whole of the frontages in the same way as manholes, gullies, and lamps.

The Metropolis Management Act, 1862, is the only Act expressly making the owners of houses and land in the street liable for the paving, etc., of intersections, and so it may be presumed that the omission of a similar provision in the Public Health Act, 1875, and Private Streets Works Act, 1892, was intentional.

The engineer should allow a fair margin for contingencies, and his estimate should be high, rather than low, as he must bear in mind that his final apportionment must not be more than 15 per cent. in excess of his estimate.

Final Apportionment. The preparation of the final apportionment is the last duty that the engineer usually has to perform, and he should exercise care that the charges in his apportionment are for the works described in the notices served upon the owners. It will not be permitted for him to lump the costs of a group of streets together, and apportion them amongst the owners of all. An apportionment, if requiring to be corrected, should be laid before his council again.



15. PLAN SHOWING APPORTIONMENTS UNDER THE PRIVATE STREET WORKS ACT OF 1892

By the time the final apportionment is ready some property will most probably have changed hands, and the engineer should bear in mind that it is his duty to make the necessary correction on the final apportionment, as the person upon whom the "provisional" notice was served cannot be made to pay if he has ceased to own the property, the charge being on the properties.

Who Pays the Bill. By the Metropolis Management Acts, the costs of paving a new street under the compulsory powers of the Acts are payable by the owners of the houses forming the street, and of the land bounding or abutting on such street, and are to be apportioned by the vestry or district board of works.

The engineer should note that the incumbent or any minister of any church, chapel, or place appropriated to public religious worship, which is by law exempt from rates for the relief of the poor, is not liable to any expenses in private streets works, as the owner or occupier of such place, nor is any expense deemed to be a charge on such church, chapel, or burial ground.

Repairs. The Public Health Amendment Act, 1907, provides that where *repairs* are required in the case of any street, not being a highway repairable by the inhabitants at large, to obviate or remove danger to any passenger or vehicle in the street, the authority may give notice in writing to the owners of the lands and premises, fronting, adjoining, or abutting on the street, and may require the owners to execute, within a time to be specified in the notice, such *repairs* as are described in the notice.

Street-Naming and House-Numbering. The Towns Improvement Clauses Act, passed in 1847, gave power to local authorities to cause names of streets to be marked or painted on a conspicuous part of some house, building, or place, and also power to compel occupiers to mark their houses with approved numbers.

Names of streets should be marked up in such a way as to be legible both by day and night. The Public Health Amendment Act, 1907, gives the authority power to paint or otherwise mark the name of a street on a conspicuous part of any building. The best description of street name-plates are white glazed china tiles, 6 in. square, on which either blue or black letters are burnt in, one letter on each tile. These are fixed by chasing them into walls of buildings, and setting in cement.

Under the Public Health Amendment Act, 1907, a local authority may, with the consent of two-thirds in number and value of the ratepayers in any street, alter the name of the street. The parties proposing to dedicate a new road laid out in rural districts as a public highway must give the engineer and surveyor of the local authority three months' notice in writing of such intention, and further construct the same in a substantial manner, and of the width required by the Act to the satisfaction of the surveyor and two justices who, on receiving such notice, shall view and certify the same, when, after being used by the public and kept in repair by the said party for a period of twelve months, such road shall become a dedicated highway repairable by the inhabitants at large.

Under the Public Health Act, 1875, the local authority may by notice in writing declare a street to be a highway repairable by the inhabitants at large, after the works specified by them have been executed, provided that no such street shall become a highway so repairable if within one month after such notice the majority of the owners of such streets object thereto.

Under the Private Streets Works Act, 1892, a local authority may take over a street in a similar manner whenever *all* or *any* of the works specified by them have been executed.

Setting out Footpaths. The model by-laws made by the Local Government Board respecting new streets require that all footpaths of a street shall be of a width not less than one-sixth of the entire width of the street. The following is an explanatory example of this requirement:

Entire width of street.		Width of path on *each* side.		Width of carriageway.	
Ft.	In.	Ft.	In.	Ft.	In.
60	0	10	0	40	0
50	0	8	4	33	4
42	0	7	0	28	0
40	0	6	8	26	8
36	0	6	0	24	0

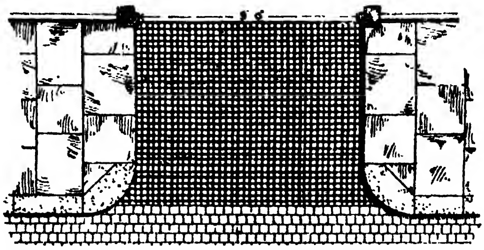
The slope (cross fall) from back edge of path towards the kerb to fall at the rate of one-half of an inch in every foot of width, if the footpath be not paved, flagged, or asphalted, and at the rate of not less than a quarter, and not more than one-half of an inch in every foot of width if the footway be paved, flagged or asphalted. In excavating to the required depth for paving the best method is to put wooden pegs so that the upper ends represent the finished surface, and then to excavate to the required depth below the top of the pegs.

In practice, paths are usually laid to the following table, which, it will be observed, complies with the above requirements.

Nature of Paving.	Cross fall, per foot of width.
Asphalt	$\frac{1}{4}$ in.
Bricks	$\frac{3}{8}$
Concrete	$\frac{1}{4}$
Gravel	$\frac{1}{2}$
Stone (artificial and natural) ..	$\frac{1}{4}$
Tar	$\frac{3}{8}$ "

The height of the kerb or outer edge of the footpath, except in cases of crossings paved or otherwise formed for the use of foot passengers, shall be not less than 3 in. at the highest part of the channel, and not more than 7 in. at the lowest part of such channel.

The reason for this requirement of the Local Government Board is that a height of less than 3 in. would render it possible for vehicles to drive on to the footpath, or for the water in the channel to overflow it, and of more than 7 in. would make it inconvenient for foot passengers.



16. PLAN SHOWING PRIVATE CARRIAGE ENTRANCE ACROSS A PUBLIC FOOTPATH

Carriage Crossings. Where it is necessary to construct a carriage-way entrance across a path, vitrified bricks or granite setts should be laid on concrete [16].

The following clause is inserted in the Public Health Act, 1907:

The provision and use of new means of access for any cattle, any beast of draught or burden, any waggon, cart, or other wheeled carriage exceeding four feet in width or two hundredweight in weight, to or from any premises fronting, adjoining, or abutting on any street which has become a highway repairable by the inhabitants at large, may, where that provision involves passage across or interference with any such part of the street as comprises a kerbed or paved footway, be allowed by the local authority on condition that the following conditions are observed:

(*a*) Every person who intends to provide the new means of access shall give notice in writing of his intention to the local authority, and shall at the same time submit, for the approval of the local authority, a plan showing the position, gradient, and mode of construction of the intended means of access;

(*b*) When the plan, with or without amendment, has been approved by the local authority, the person may, upon receiving notice of their approval, proceed to execute the necessary works, but those works shall be executed under the supervision and to the reasonable satisfaction of the local authority, and in accordance with the plan as approved by the local authority;

(*c*) After the completion of the works the new means of access may be used, subject to the conditions which, in pursuance of any provisions of the law relating to highways, attach to the use for the like purpose of any carriage way forming part of a highway repairable by the inhabitants at large.

Asphalt. Asphalt is largely employed as a paving material for footways. It makes an excellent footpath, being durable, non-slippery, expeditiously laid, pleasant to walk upon, and not glaring to the eyes.

Unfortunately, on account of what is technically termed *creeping*, it cannot be laid on paths having a considerable inclination, or cracks occur with increase.

Mastic asphalt is more commonly used upon footpaths than *compressed* asphalt. Asphalt, properly so called, is a natural compound of carbonate of lime and bitumen, and is found principally in volcanic areas, the proportion varying from 7 per cent. bitumen and 93 per cent. carbonate of lime to 20 per cent. bitumen and 80 per cent. carbonate of lime. Men of erudition have asserted that it was the pitch used to make the ark watertight, and that it

was the slime used as a mortar in the construction of the Tower of Babel.

Manufacture of Mastic Asphalt. The process of manufacture into a mastic or semi-liquid state is as follows: the pieces of raw rock, weighing ¼ cwt. to ½ cwt. each, are placed in an asphalt crusher, where they are broken into small pieces. After passing through the crusher, the asphalt is carried up by elevators to the disintegrators, which run at a speed of 1,800 revolutions per minute, and is ground to a very fine powder.

This powder is then put into specially-made cauldrons, and gently boiled and worked by agitators with certain proportions of refined bitumen (added as a flux), and when heated to a temperature of about 400 F., a mixture of fine Bridport grit is added (in making mastic asphalt), and then roughly incorporated with the asphalt by the rotary working of the agitators. It is then turned out into iron moulds, forming the well-known cakes, which weigh about ½ cwt. each. These cakes are broken up into pieces on the site where the asphalt is to be laid, and placed into small portable cauldrons with just sufficient bitumen as flux, and, when properly heated, the asphalt mastic is ready to be spread over the cement concrete surface to the thickness required. It is then turned into iron moulds, forming the well known cakes, which weigh about 56 lb.

Asphalt Laying. These cakes are usually sent by the manufacturers to the site where the paving is to be laid, and here they are remelted in small round street boilers on wheels with a fire under them, to which is added from 30 to 40 per cent. of fine, clean, dry limestone grit. If silicious grit only can be obtained, it should be as fine as sea sand. When ready for use it should be hot enough to vaporise a drop of water. It is carried in pails, and spread, by means of wooden hand floats, over a prepared smooth foundation of 3 in. of concrete (6 to 1) previously allowed to dry. Silver sand is then spread sparingly over the surface and rubbed in by floats. In six hours the footway is ready for traffic. One ton of asphalt covers 30 sq. yd. when laid 1 in. thick, which is the usual thickness adopted for paths. The advantages of asphalt pavements are durability, a smooth surface unbroken by joints, a good foothold, even and regular wear, and an impervious character.

Owing to the substitution of inferior material made from gas tar, Stockholm tar, hard pitch, and ground limestone mixed with bitumen as asphalt, it is essential that the asphalt to form the pavement should be specified to be composed of pure natural rock taken from the mines of the French (or other approved) Asphalt Company.

Bricks. Blue brick-paving for footpaths is one of the oldest materials. Buff granite vitrified bricks, made solely from the fine granite clays of South Devon, have come into general use chiefly owing to their toughness, and their colour, which gives an improved appearance to the paving, presenting a very bright and pleasing effect when laid. Methods of laying bricks to various patterns are shown in 17.

The first essential is the right material, which will produce a tough and hard brick, and this must be treated in a way to develop its best qualities and avoid the defects which in many instances have given paving-bricks a bad name. The firing must have the most careful attention, or in this process the best of material treated by the best methods will be rendered worthless for paving.

Paving-bricks differ from ordinary bricks in that they are thinner, being only 2 in. thick, and are also harder and more compact.

Concrete. By concrete or cement paving is meant the inch of fine stuff which is laid on a coarse concrete foundation.

The use of concrete, as a monolith, as a paving material for footpaths, has made great progress during recent years, and in nearly every town in the United Kingdom, more or less, concrete may now be seen as a pavement. It is one of the cheapest and most durable paths which can possibly be formed.

The following may be taken as a fair description of the manner in which in situ concrete footpaths should be constructed.

Laying Concrete Footpaths. The foundation is excavated to a depth of about 6 in. below the finished level, and a bed of gravel 1 in. in thickness is then laid. A thickness of about 3 in. of clean hard stone is next laid, and well watered and rolled. The footpath is then divided into bays 6 ft. in width with strips of soft wood, and each alternate bay completed by laying upon the stone foundation 2 in. of carefully-prepared concrete composed of one part Portland cement, two parts coarse clean gravel, or other suitable material, passed through a 1-in. screen, and two parts of clean, sharp sand, which must be well beaten into place; and before it is set a finishing coat 1 in. in thickness of concrete, composed of one part Portland cement to two parts granite chippings, is added and brought up to the finished surface of the footpath, being well trowelled and smoothed into place. The strips of wood are removed as the work is finished.

The concrete is thus laid in bays to allow for expansion and to prevent the surface from cracking or gaping open, which is liable on the changes of temperature on large exposed surfaces.

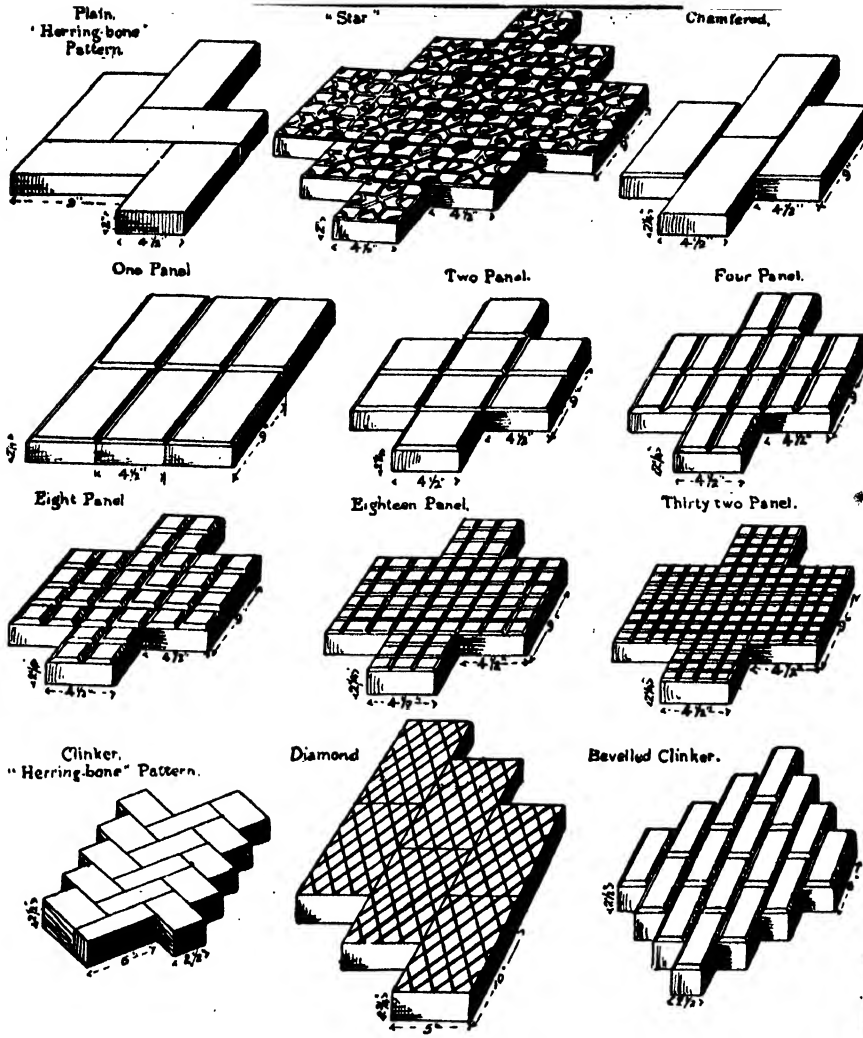
Laying Concrete Paving. In laying insitu concrete paving, the following points should be observed:

(*a*) From October to March is an unsuitable time for laying, owing to the frosty weather.

(*b*) It is better to avoid extreme heat, as the sun takes the moisture out of the upper face before the cement has time to set.

(*c*) It is advisable that the ground should be wetted before it is laid, and the finished surface should be protected by damp bags or planks for a week or two before being used for traffic.

(*d*) Beach shingle is preferable to crushed granite, but the sand should be carefully screened from the shingle.



17. CANDY'S BUFF VITRIFIED PAVING BRICKS, SHOWING MANNER OF LAYING

One ton of Portland cement mixed in the proportion of 6 to 1 will cover an area of 42 superficial yards, 6 in. thick.

One cubic yard mixed as above will require 3¾ cwt. of cement, 9 cwt. of sand, 18 cwt. of gravel, and 40 gallons of water.

Fourteen labourers mixing and laying concrete will complete about 135 superficial yards per day of 10 hours.

Stuart's Granolithic. *Stuart's Granolithic* is one of the best known monolith pavings. Granolithic is the name that was coined for the paving by the inventor, who, knowing its great value and qualities, patented it throughout the world.

The surface is indented by the use of a spiked roller, with a view of preventing slipperiness.

During 17 years that a piece of this paving was laid in Leadenhall Street, London, it was computed that 52,000,000 people passed over it without any signs of wear being visible, and in 1892 a test was made of a portion of the said paving, when 1 sq. ft. was crushed at 562·4 tons.

The paving consists of a layer of Thames ballast concrete, 2 in. thick, laid on a foundation of 4 in. of clinker or brick rubble. On the ballast concrete a layer of granite concrete 1 in. thick is laid, each layer being well worked so as to remove cavities. The surface of the last layer is trowelled to a fair face, which is then sanded and rolled. The concrete is laid and finished off in panels, and can be left either in grey or red colour.

Gravel. Pebble pitching was much used in the earlier periods, and some portions still remain in old county towns. Gravel paths are only suitable for suburban districts. They must be well bottomed with dry rubble, well drained and rolled.

Hoggin from stone quarries, or gravel obtainable from Sevenoaks or Croydon, is the best material for binding and forming a good surface.

A good path for country roads and lanes, and one which is found to be firmer and more comfortable to pedestrians than ordinary gravel and beach paths, is made to the following abbreviated specification:

Foundation. Well formed and left loose.

Bottom Layer. Four inches of chalk, brick rubble, coarse clinkers from furnaces, or iron clinkers from a local foundry, well watered and rolled.

Second Layer. Two inches of fine ashes well consolidated.

Top Layer (Finished surface). One inch of finely-sifted ashes, *burnt brickdust, or macadamised road siftings, well watered and rolled.

Such a path will wear well, but it is liable to a growth of vegetation.

Artificial Stone. The manufacture of artificial stones is not altogether to be classed as a new art, for our forefathers made use of lime burnt from cockles and other shells to mix with sand. A strong material was made from *terra puzzolana*, imported from Civita Vecchia, and it was with this that John Smeaton cemented together the granite blocks of the Eddystone Lighthouse two centuries ago. As a paving material the merits of Victoria stone cannot be surpassed. It is composed of finely-crushed granite from Groby, in Leicestershire (washed by patent machinery), and Portland cement, carefully selected, and is manipulated and moulded, and subsequently steeped in a patent solution of natural, soluble silica, by which it is hardened, and rendered practically non-porous.

The crystals of the Leicestershire granite are regular in character, being of moderate size, and well cemented by a paste, which the analysis shows to be unusually free from destructive alkaline ingredients. The small size of the pieces of granite used in this manufacture renders the presence of the alkalies practically innoxious, because the artificial cement used surrounds these pieces with a protective coating, and prevents the possibility of any dissolving action by the air or moisture.

Making Artificial Stone. Sample lots of Portland cement are taken and made into briquettes, having a breaking surface of 1 sq. in. These briquettes are exposed to the air for 24 hours and then immersed in water, where they remain for six days, when they are tested by a double-lever testing machine.

The aggregate and cement, having become in a manner guaranteed by the treatment and precautions described, are mixed together in a dry state by machinery, and the water is then added in a careful manner, so as to avoid the danger of washing out any of the fine and more soluble portions of the cement; and before any initial set of crude concrete mixture can arise it is put into the moulds, in which it is carefully worked, in order to fill up the angles and sides, thus ensuring accurate arrises all round. After having remained in the moulds a sufficient length of time, they are taken to the tank in the silicating yard (protected from the weather), and covered by the silicate solution, where they remain until the proper beneficial properties have been imparted.

The machinery required for the conversion of the crude silica into silicate is of a special character. The caustic soda is obtained from the best sources and of the purest quality, because the presence of sulphur, which sometimes exists in carelessly manufactured soda, has a most prejudicial influence on the silicate.

The slabs, after being taken from the tanks, are stacked in the yard, where they remain to season, and are taken away in order of their age.

Varieties of Artificial Stone Slabs. Paving slabs are made of various sizes and thicknesses; those of 2 in. weigh 25 to 26 lb. the foot super, and are convenient to handle.

Street corners are made with patent slabs moulded to radiating and other rectangular shapes to fit the radius, and the difficulties and waste attending cutting the stone at random are avoided [18].

The granite used for the *Imperial* slabs is a mixture of Aberdeen, Guernsey, and Guenast (Belgium).

The *Adamant* slabs are composed of finely-crushed Aberdeen granite and Portland cement. Other artificial stone slabs are composed of finely-broken granite York stone chippings from stone slag and destructor clinkers mixed very accurately with Portland cement and subjected to different processes. Municipal authorities largely manufacture their own artificial slabs by the use of hydraulic artificial stone presses, and with a staff of three men an average of 35 slabs, measuring 3 ft. by 2 ft., can be manufactured in an ordinary working day.

Laying Artificial Slabs. Much depends on the way in which such slabs are laid. Before laying, the area to be paved should be excavated, or filled in with good dry material well rammed, as may be required to suit the intended levels of the path. On this a layer of poor hydraulic lime-mortar is spread, on which the slabs are well and truly bedded. The slabs should be of such dimensions as to break joint when laid [18]. Care should be taken to allow between the paving and building a little space (say, ½ in.), which should be filled in with sand, so as to allow for any disturbance of the ground caused by frost. When laid, the slabs should be run in with grout made from mortar similar to that used for bedding.

Where the natural ground is of clay or chalk it is advisable to put in a layer of ashes or broken clinkers, 3 to 4 in. in depth, to form a dry foundation under the slabs.

The percentage of material broken or cracked in lifting and relaying over pipe trenches is found to be greater with artificial stone than with natural stone. This is partly accounted for by the close joints of the artificial slabs and the brittle nature of concrete. The average waste in artificial stone is estimated at about 3 per cent., but this depends very largely on the manner of bedding and jointing, and on the care used in laying, lifting, and relaying.

Wear of Artificial Stone. Artificial slabs are not found to be more injuriously affected than natural stone by severe frost, and for busy streets this paving is pushing in situ concrete paving out of the field, owing to the practicability of lifting and replacing when electric light, gas, or water trenches have to be taken under the pavement.

The period allowed by the Local Government Board for repayment of loans for artificial pavement seems now to be about the same as that for natural stone. Formerly a shorter period for repayment was given, but this doubtless depends upon the special circumstances in each case.

Natural Stone. For many generations York stone flagging was regarded as the criterion material for footpaths. Without doubt it is the most comfortable to walk upon.

York stones of 3 in. thickness, after being laid for twenty-five years in Kensington, where a large quantity of this stone is laid, were taken up, refaced, resquared, and relaid in a subsidiary street, where they are likely to last another fifteen years, and the best of it can then be worked into narrow strips for path edging round public parks and pleasure grounds, the remainder coming in useful for road foundation.

It will thus be seen that York has several lives. Lazonby (Cumberland) flags have been in use in Carlisle from time immemorial; they are very durable, and when laid on a good foundation, on a 1-in. bed of good mortar, have been known to wear evenly down from 3 in. to $1\frac{3}{4}$ in. in thickness; but it is very difficult to get these flags of the same quality as thirty years ago, though whole mountains have been rooted into. Caithness (Scotland) flags are the other only natural stone to compete with York. It has been ascertained that the resistance to a gradually increased bending stress between York and Caithness flagging is in favour of the latter.

In the West of England the Devonian limestone flagging is much used.

The foundation for flags should be good. Hard core is that most generally employed, and, owing to the uneven surface of all flags, it is necessary to bed on sand. The joints should be set flush, and each stone pointed in properly mixed blue lias mortar.

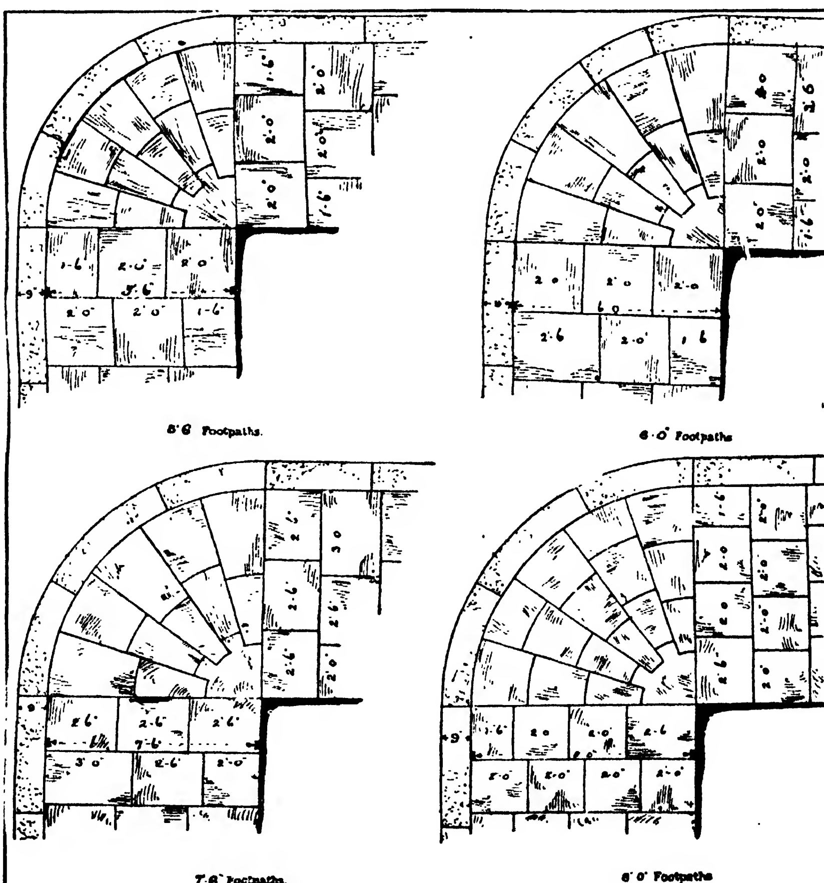
Tar. Tar-paved footpaths are undoubtedly the most popular formation where the traffic is not too heavy, and the manufacture and laying of this class of paving deserves much more attention at the hands of local authorities and their engineers than is generally bestowed on them.

Manufacturers of tar paving will as a general rule supply and lay their own mixture, roll and leave in a satisfactory condition, giving a written guarantee for five years.

Making Tar Paving. In manufacturing tar paving the common practice is to heat the stone (Kentish ragstone, Derbyshire limestone, chippings or gravel) proposed to be used in a heap or clamp, the clamp being fired at the bottom, and coke breeze or small coke being mixed with the stone. When the fire is exhausted the clamp is allowed to remain for a few days while it cools, and the heat gets more uniformly distributed.

Another practice is to heat the stone on a hot hearth, on which the stone can be raised to such a temperature that it will absorb as much tar as possible without ignition. Hot tar is added to the heated stone, and the same turned over with hot shovels until all parts of the stone are well coated. Tar paving thus made should be stored for at least three months before being used. In storing, care should be taken to keep it as free as possible from damp.

Tar paving is improved if kept for a year or two, although the nature of the tar, to all appearances, has disappeared. It can be freshened with a little refined tar before being used.



18. PATENT ARTIFICIAL STONE SLABS FOR STREET CORNERS

Foundation for Tar Paving. The stones used should be of uniform size, machine broken, and screened; those for the bottom layer should not exceed 1 in. in diameter, and all the stones used should be retained on a sieve of $\frac{5}{8}$ in. mesh. The stones for the top layer should pass through a sieve having $\frac{3}{8}$ in. mesh, and be retained on a sieve of $\frac{1}{8}$ in. mesh.

The ground of the area proposed to be tar paved should be levelled, allowing for a fall of not less than 1 in. in 3 feet.

The foundation on which the tar paving is to be laid should be composed of broken brick, ashes, or other similar hard core, not less than 3 in. in thickness, and well rolled until solid, with a fairly smooth and level surface. In situations where there is an existing foundation of gravel or other suitable material, this requires to be levelled only to falls as mentioned above for "ground-work," and well rolled; all soft places excavated and made good with suitable hard core, as previously specified for new foundations.

Laying Tar Paving. The tar paving should be laid in two coats, each coat being separately well rolled with a roller weighing not less than 12 cwt. The bottom coat should consist of material of $1\frac{1}{4}$ in. gauge, and the top coat of material of $\frac{3}{8}$ in. gauge. The surface, when being finished, ought to be sprinkled with white Derbyshire spar of $\frac{1}{2}$ in. gauge, and before final rolling, dusted over with finely screened spar or limestone dust, to leave a white smooth surface on completion.

The thickness of the work should vary according to the traffic for which it is intended, and should generally agree with those given below for the various purposes mentioned—namely:

PATHS (*with ordinary traffic*).

Work to be laid $2\frac{1}{2}$ in. thick.

Bottom coat $1\frac{3}{4}$ in. thick, of $1\frac{1}{4}$ in. gauge material.

Top coat $\frac{3}{4}$ in. thick, of $\frac{7}{16}$ in. gauge material.

PATHS (*with light traffic*).

Work to be laid 2 in. thick.

Bottom coat $1\frac{1}{2}$ in. thick, of $1\frac{1}{4}$ in. gauge materials.

Top coat $\frac{1}{2}$ in. thick, of $\frac{7}{16}$ in. gauge material.

Tarring and sanding (or, as it is termed, "dressing") the surface of tar paths should be done during dry weather, the first summer after the tar paving is laid, and afterwards triennially.

The tar used for this purpose should be well seasoned, or refined tar, heated in a caldron, with a little pitch. After the surface of the path is swept clean, and the hot tar well rubbed in, a layer of dry sharp sand, about [illegible] thick, is spread on the tar so as to keep it from adhering to pedestrians' feet. This sand works into the tar, and forms a thin coating, which preserves the life of the path considerably.

Tar pavements must not be compared with asphalt or paved paths, but only looked upon as a substitute.

A. TAYLOR ALLEN

Roads concluded

STATISTICS OF COST AND WEAR OF MATERIALS USED FOR FOOTPATHS

Paving.	Description of Paving.	Thickness in inches.	First cost per superficial yard.	Average cost of maintenance per superficial yard	Life of paving in years.	Remarks.	Number of years usually allowed by Local Government Board for repayment of loan.
Asphalt	(Concrete foundation)	3	—	—	—		—
	Asphalt ..	1	7.9 to 8.6	—	18	The cost is dependent on the quantity required.	10
	" ..	$\frac{3}{4}$	6.6 to 7.0	—	15		
	" ..	$\frac{1}{2}$	5 6 to 6.0	—	12		
Bricks	Blue	2	5.0 to 6.0	—	12	This paving can be laid at a much less cost in Staffordshire and the Midlands.	10 to 15
	Buff	2	5.0 to 6.0	—	—	—	—
	Red	2	3.6 to 5 6	—	—	—	—
Concrete ..	Insitu	3	3/0 to 4.0	—	—	Strength of the matrix has to be taken into account.	10 to 15
	"	2	2.0 to 3.0	—	—		
Gravel	Ordinary ..	4	1,0	1d.	3	Cost depends on locality and materials obtainable.	5
Stone (artificial)	Adamant flags	2	5.0	—	12 to 14	—	—
	Imperial ,,	2	4/9	—	12	—	10 to 20 (according to composition of material).
	,, insitu	2	4.0	—	—	—	
	Stuart's flags	2	5 6	—	—	—	
	,, insitu	2	4 0	—	—	—	
	Victoria flags	2	6/0	—	15 to 20	—	
	York (hard) ,,	$2\frac{1}{2}$	7/0	—	—	—	
Stone (natural)	York ,,	3	8.6	$4\frac{1}{4}$d.	25	1s. per yard less if laid on a ballast foundation instead of concrete, and considerably less when laid in Yorkshire and North of England.	20
	,, ,,	$2\frac{1}{2}$	7/3	—	20		
	,, ,,	2	6/6	—	15		
Tar	Limestone ..	3	2/6	$\frac{1}{2}$d.	10	A cheaper material is laid in some localities.	10

From Dr. Johnson to Adam Smith. Writings of Burke and Gibbon. The Secret of Style. Letters of Lord Chesterfield.

EIGHTEENTH CENTURY PROSE

Dr. Johnson. SAMUEL JOHNSON (b. 1709; d. 1784), poet, essayist, dramatist, biographer, critic, novelist, lexicographer, and the "great Cham" of English literature, cannot be considered here in relation to his unrivalled position as a great and wise talker. There is only one way of realising Johnson's greatness: by mastering Boswell's biography. As to his influence on prose literature, Macaulay says: "His constant practice of padding out a sentence with useless epithets till it became as stiff as the bust of an exquisite; his antithetical forms of expression, constantly employed even where there is no opposition in the ideas expressed; his big words wasted on little things; his harsh inversions, so widely different from those graceful and easy inversions which give variety, spirit, and sweetness to the expression of our great old writers—all these peculiarities have been imitated by his admirers, and parodied by his assailants, till the public has become sick of the subject."

Gibbon, the historian of Roman decadence, lived to write; Johnson, an infinitely greater man, wrote to live. Today, Johnson's "Lives of the Poets" are read more, perhaps, than anything he wrote, but not for the accuracy of their data or their infallibility of judgment. They disclose to us not fine literary instinct so much as fine human sympathy. His prose tale of "Rasselas, Prince of Abyssinia," written to defray the cost of his mother's funeral, has been aptly described as a prose version of his poem on "The Vanity of Human Wishes." His great "Dictionary" was the first of its kind. It stands almost alone as the work of one man. Its value and influence have been great; and even today, except for its weakness on the side of etymology, a weakness due to the fact that Johnson's Latin learning was not approached by his knowledge of Anglo-Saxon, it is a standard book of reference. The ordinary reader should have some acquaintance with the "Lives of the Poets;" and "Rasselas" he is not likely to miss. For the rest, to know this grand old character in Boswell's biography is, as it was to love "Aspasia," "a liberal education."

Oliver Goldsmith. The friendship between Steele and Addison was not greater than that between Johnson and OLIVER GOLDSMITH (b. 1728; d. 1774). But no greater contrast could be imagined than that afforded by the writings of the two men. "In prose style, as in poetic," says Mr. Gosse, "it is noticeable that Goldsmith has little in common with his great contemporaries, with their splendid burst of rhetoric and Latin pomp of speech, but that he goes back to the perfect plainness and simple grace of the Queen Anne men. He aims at a straightforward effect of pathos or of humour, accompanied, as a rule, with a colloquial ease of expression, an apparent absence of all effort or calculation." Goldsmith's prose approximates to that of Addison. The best examples of it are to be found in his "Citizen of the World" and the "Vicar of Wakefield." The first-named work consists of a series of letters supposed to have been written by a Chinaman resident in London, who was jotting down his experiences for the benefit of his friends in the Far East. The idea was not original, and it has since been imitated by innumerable writers, but the delightful wit and humour of Goldsmith's work have never been excelled. Ninety-eight of the letters appeared in the periodical called the "Public Ledger" in 1760. Twenty-five more were added when the letters were printed in volume form in 1762. The "Vicar of Wakefield," Goldsmith's chief prose work, must be considered in its relation to the history of the English novel, which forms the most important part of our future study.

Historians and Philosophers. A number of historians, philosophers, theologians, and essayists must now be dismissed with the briefest possible mention.

ANTHONY ASHLEY COOPER, third Earl of Shaftesbury (b. 1671; d. 1713), wrote a volume entitled "Characteristics of Men, Manners, Opinions, Times." The views expounded in it influenced the Scottish philosopher Hutcheson, attracted attention on the Continent, and found reflection in Pope's "Essay on Man." HENRY ST. JOHN, first Viscount Bolingbroke (b. 1678; d. 1751), occupied himself with that side of philosophy affected by Shaftesbury, but is better known as a statesman. GEORGE BERKELEY, Bishop of Cloyne (b. 1685; d. 1753), was a man whose life, apart from his writings, is full of interest. As a philosopher he aimed at the overthrow of materialism. He was an acute and original thinker, possessed a style of great force and elegance, and he is one of our most accomplished writers of dialogue. JOSEPH BUTLER, Bishop of Durham (b. 1692; d. 1752), was the author of a work on the "Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature," which won for him the name of "The Bacon of Theology," and remains a standard work in its own department of inquiry. DAVID HUME (b. 1711; d. 1776) was distinguished as an essayist, a philosopher, and a historian. Possessing wonderful clearness of mental vision, his style is marked by exceptional lucidity. An opponent of popular government, he was yet the first of our writers to recognise the importance of the social and scientific as

well as the constitutional and political factors in the making of history. His influence as a philosopher was not inconsiderable in Scotland and Germany. The REV. WILLIAM ROBERTSON (b. 1721; d. 1793) was a painstaking historian of "Scotland," "Charles V.," and "America."

Gibbon's Great Work. EDWARD GIBBON (b. 1737; d. 1794) dedicated the best part of his life to the writing of his monumental history of "The Decline and Fall of the Roman Empire," and has been described as the one historian of his time "whom modern research has neither set aside nor threatened to set aside." The magnitude of his subject "is nobly sustained by the dignity of the treatment. The glowing imagination of the writer gives life and vigour to his rounded periods and to the stately and pompous march of his narrative. Perhaps his unique merit is his supreme and almost epic power of moulding into a lucid unity a bewildering multitude of details, and giving life and sequence to the whole." Gibbon's great work, begun in 1768, was completed in 1788. The following brief passage, referring to the foundation of Constantinople, illustrates some of the chief features of the historian's style:

"The prospect of beauty, of safety, and of wealth united in a single spot was sufficient to justify the choice of Constantine. But as some mixture of prodigy and fable has in every age been supposed to reflect a becoming majesty on the origin of great cities, the Emperor was desirous of ascribing his resolution not so much to the uncertain councils of human policy as to the eternal and infallible decrees of Divine wisdom. In one of his laws he had been careful to instruct posterity that in obedience to the commands of God he laid the everlasting foundations of Constantinople; and though he has not condescended to relate in what manner the celestial inspiration was communicated to his mind, the defect of his modest silence has been liberally supplied by the ingenuity of succeeding writers, who describe the co-eternal vision which appeared to the fancy of Constantine as he slept within the walls of Byzantium." "The Decline and Fall" is one of the inevitable items in any list of "books to read."

Burke's Command of Prose. EDMUND BURKE (b. 1729; d. 1797) was, like Bolingbroke, a statesman and orator as well as an author. Matthew Arnold has described Burke as the greatest master of English prose style that ever lived. Mr. Gosse says: "Notwithstanding all its magnificence, it appears to me that the prose of Burke lacks the variety, the delicacy, the modulated music of the very finest writers. . . . The greatest of English prose writers, we may be sure, would be found to have some command over laughter and tears, but Burke has none. . . . In short, the prose of Burke may be felt to be the finest expression of a particular phase of the eighteenth century mind—a phase from which all the coarse fibre of the Renaissance, to its very last filament, had been extracted, where all is civilised, earnest, competent, and refined, but where the imagination is almost too completely under control."

Apart from his speeches, Burke's principal prose works are: "A Vindication of Natural Society," written to ridicule Bolingbroke's views on religion; an "Inquiry into the Sublime and the Beautiful," and "Reflections on the Revolution in France" (1788). In the last-named work Burke set forth with much impressiveness his view that constitutional government, not revolution, was the true remedy for the troubles of the French nation. Here is a striking extract:

Specimen of Burke's Writing. "It is now sixteen or seventeen years since I saw the Queen of France, then the Dauphiness, at Versailles; and surely never lighted on this orb, which she hardly seemed to touch, a more delightful vision. I saw her just above the horizon, decorating and cheering the elevated sphere she had just begun to move in—glittering like the morning star, full of life and splendour and joy. Oh! what a revolution! And what a heart must I have to contemplate without emotion that elevation and that fall! Little did I dream, when she added titles of veneration to those of enthusiastic, distant, respectful love, that she should ever be obliged to carry the sharp antidote against disgrace concealed in that bosom. Little did I dream that I should have lived to see such disasters fallen upon her in a nation of gallant men, in a nation of men of honour and of cavaliers. I thought ten thousand swords must have leaped from their scabbards to avenge even a look that threatened her with insult. But the age of chivalry is gone. That of sophisters, economists, and calculators has succeeded, and the glory of Europe is extinguished for ever. Never, never more shall we behold that generous loyalty to rank and sex, that proud submission, that dignified obedience, that subordination of the heart which kept alive, even in servitude itself, the spirit of an exalted freedom. The unbought grace of life, the chief defence of nations, the nurse of manly sentiment and heroic enterprise, is gone! It is gone—that sensibility of principle, that chastity of honour, which felt a stain like a wound, which inspired courage whilst it mitigated ferocity, which ennobled whatever it touched, and under which vice itself lost half its evil by losing all its grossness."

Importance of Studying Burke. Of all the eighteenth century writers, perhaps Burke is the one whom the student can least afford to neglect. De Quincey, who was no hasty eulogist, considered him the supreme writer of his time. Whether that judgment can be entirely justified it is not easy to show, unless we could enter at much greater detail into comparisons between Burke and his contemporaries; but the fact remains that for much that makes for true citizenship as well as for the literary graces the student must have recourse to the works of Edmund Burke—his speeches not less than his writings. He helps us marvellously to a clear understanding of the public life of our country, though he may not always convince us.

We must not be content, however, with knowing Burke in "The Sublime and the Beautiful"; his "Reflections on the Revolution in France," though far less known to the ordinary reader, is even more worthy of study, and his speeches present a rich field whence we may glean knowledge of life and wisdom.

Horace Walpole and Adam Smith. HORACE WALPOLE, fourth Earl of Orford (b. 1717; d. 1797), set up a private press, whence he issued "A Catalogue of Royal and Noble Authors." He also wrote "Anecdotes of Painting in England;" a tragedy, "The Mysterious Mother," and a romance entitled "The Castle of Otranto." He left nearly 3000 letters and a "History of the Last Ten Years of the Reign of George II." Walpole possessed a brilliant style, which will serve to keep his works alive and render his letters readable independently of their historical value.

ADAM SMITH (b. 1723; d. 1790) wrote a work entitled "The Wealth of Nations," which originated the study of "political economy" as a distinct branch of science, inspired a world-wide interest in the sources of wealth, and was responsible for the rise of the theory of Free Trade. "The Wealth of Nations" is a book that may still be studied with pleasure and profit. It affords an example of the way in which a "dry" subject may be treated so as to appeal to the popular mind.

We have now learned enough to realise that the study of English prose must be pursued on lines different from those on which we undertook the study of English poetry; whereas poetry is universally the voice of inspiration, prose in its development departs from the sphere of literature proper. Sometimes retaining but frequently losing its claim as literature, it becomes in turn the servant of theology, the handmaid of history, the medium of science, the channel of philosophy—essential alike to religious and atheistical propaganda, to practical and to theoretical ends.

A Parting of the Ways. At the beginning of the eighteenth century the student stands at a parting of the ways. He has to distinguish between what is prose literature and what is not. To a certain extent the answer will depend upon his own bent or "humour." But he still has to ascertain why and when and by whom particular books were written. He must learn not only the history of those books, but become acquainted with their relationships—their position in regard to the treatment by others of the subjects with which they deal—before he is able to satisfy himself as to their value. A French book of scientific, theological, historical, or philosophical importance is usually of literary importance also. The rule in France is, however, the exception in England.

We must strongly urge the advisability of some study of the political and social developments of which particular books were either a cause or an outcome.

The Secret of Style. Charm and distinction of style are peculiarly characteristic of our eighteenth century prose. The century "found English prose antiquated, amorphous, without a standard of form; it left it a finished thing, the completed body for which," as Mr. Gosse says, "subsequent ages could do no more than weave successive robes of ornament and fashion." Style, however, implies something more than precision of form. Good style is inseparable from appropriateness of diction. For example, the great writer does not approach great themes with a string of light colloquial sentences, any more than one would appear at a funeral attired in fancy dress. To appreciate style one must bring to it a knowledge of grammatical rules. But grammar is not all. Ideas are not all. The secret of style lies in the character of the man behind the writing. For this reason, while we can but admire the finished grace of a Chesterfield, Johnson, with all his heaviness, compels our affection.

Eighteenth Century Characteristics. The wider our knowledge of the literature of this period grows, the clearer shall we see the injustice of the common indictment of the age as one of shams and sentiment. Apart from the influence of Johnson, the age of Berkeley and Wesley and Whitefield cannot truthfully be described as devoid of healthy enthusiasm or activity. It was the age of our great historians. It was adorned by some of our greatest philosophers and keenest critics. If it questioned the bases of religion, it quickened both faith and good works.

English writers of this notable period influenced Continental thought more, perhaps, than did the writers of any other period of our history. Eighteenth century England, as we have already seen, discovered Shakespeare before the Germans. It standardised the essay, sowed the seeds of modern Nature-study and modern chemistry, gave birth to our first great novel, laid the foundations of our periodical literature, stood sponsor to the beginnings of daily journalism, and crushed the system of literary patronage. It was the age, also, of political economy and of public eloquence.

Chesterfield's "Letters to His Son." The eighteenth century is also rich in its letters. The correspondence of Horace Walpole has been already referred to. PHILIP DORMER STANHOPE, fourth Earl of Chesterfield (b. 1694; d. 1773), was a statesman and wit who is remembered today chiefly for his "Letters to His Son." Given to the world in 1774 by the son's widow, these letters were described by Johnson as displaying the morals of a courtesan and the manners of a dancing-master. They argue, nevertheless, despite their worldliness, a sincere solicitude for the welfare of the son to whom they were addressed. A great French critic, Sainte-Beuve, has said of them: "If Horace had a son, I imagine that he would address him in this way, and no other." Here is a representative example of Chesterfield's style:

"Style is the dress of thoughts; and let them be ever so just, if your style is homely, coarse, and vulgar, they will appear to as much disadvantage, and be as ill-received as your person, though ever so well proportioned, would, if

dressed in rags, dirt, and tatters. It is not every understanding that can judge of matter, but every ear can and does judge more or less of style; and were I either to speak or write to the public, I should prefer moderate matter, adorned with all the beauties and elegancies of style, to the strongest matter in the world, ill-worded and ill-delivered. . . . A person in the House of Commons, speaking two years ago upon naval affairs, asserted that we had then the finest navy *upon the face of the earth.* This happy mixture of blunder and vulgarism, you may easily imagine, was matter of immediate ridicule; but I can assure you that it continues so still, and will be remembered as long as he lives and speaks. Another, speaking in defence of a gentleman upon whom a censure was moved, happily said that he thought that gentleman was more *liable* to be thanked and rewarded than censured. You know, I presume, that *liable* can never be used in a good sense.

"You have with you three or four of the best English authors, Dryden, Atterbury, and Swift; read them with the utmost care, and with a particular view to their language, and they may possibly correct that curious infelicity of diction which you acquired at Westminster. . . . . Cicero says, very truly, that it is glorious to excel other men in that very article in which men excel brutes, speech. . . . Gain the heart or you gain nothing; the eyes and the ears are the only road to the heart. Merit and knowledge will not gain hearts, though they will secure them when gained. . . . If you have not a graceful address, liberal and engaging manners, a prepossessing air, and a good degree of eloquence in speaking and writing, you will be nobody, but will have the daily mortification of seeing people with not one-tenth of your merit or knowledge, get the start of you and disgrace you both in company and in business."

Chesterfield's Style. Much might be written of the argument set forth in the foregoing extract. It is quoted for its own sake, but the passage is given also as an example of writing that is at once clear, simple, forcible, and polished. The aim of the writer is apparent throughout. The means he adopts to further that aim are direct. He describes things that are desirable and against them sets the means by which they are to be attained. The chance that ambition may not be sufficiently stimulated is provided for by the closing appeal to fear—the fear of ridicule. Lord Chesterfield uses the words "happy" and "happily" in the now obsolete sense of "accidental" and "accidentally."

Johnson's Famous Letter. By way of contrast to Chesterfield's appeal to selfish instincts may be given part of the famous letter in which Johnson repudiated the patronage which, though it was offered when his "Dictionary" was completed, was—possibly through the indiscretion of a servant—refused when that work was originally planned. Johnson's letter was written after the appearance, in a periodical called "The World," of two papers by Lord Chesterfield recommending the Dictionary to the public.

"Seven years, my Lord," wrote Johnson in 1755, "have now passed since I waited in your outward rooms, or was repulsed from your door; during which time I have been pushing on my work through difficulties, of which it is useless to complain, and have brought it at last to the verge of publication without one act of assistance, one word of encouragement, or one smile of favour. Such treatment I did not expect, for I never had a Patron before."

Johnson, it should be explained, had inscribed the "Plan" of his Dictionary to Lord Chesterfield after some intimation had reached him indicating that that nobleman was interested in the project. His letter continues:

"Is not a Patron, my Lord, one who looks with unconcern on a man struggling for life in the water, and, when he has reached ground, encumbers him with help? The notice which you have been pleased to take of my labours, had it been early, had been kind; but it has been delayed till I am indifferent, and cannot enjoy it; till I am known and do not want it. I hope it is no very cynical asperity not to confess obligations where no benefit has been received, or to be unwilling that the Publick should consider me as owing that to a Patron which Providence has enabled me to do for myself."

Lord Chesterfield, to show that his withers were unwrung, laid this letter open upon his table for others to see. Johnson, pressed for a copy of it, continually refused to give one, remarking on one occasion: "No, sir; I have hurt the dog too much already." Johnson saw through the veneer of Lord Chesterfield's bearing the shrivelling heart of a bitterly disappointed man.

Other Letter-writers. Among other letter-writers of the eighteenth century must be named the poets COWPER and GRAY. The letters of Cowper afford, perhaps, the best argument against the effectiveness of ornamental diction when it is confronted with a style that is simple and sincere. Cowper's delightful letters describe in the most natural and most charming of language the surroundings and incidents of the poet's life at Olney and Weston. Gray's letters possess the qualities of the bookman and the scholar, and represent a man who seems never to have permitted himself to appear in "dressing gown and slippers." The "Letters" of LADY MARY WORTLEY MONTAGU (b. 1689; d. 1762), describe in the simple and elegant style of an accomplished if worldly woman her experiences of travel in Europe and the Near East between 1716 and 1718. Though circulated in MS. during her lifetime they were not printed until a year after her death. The "Natural History of Selborne," by GILBERT WHITE (b. 1720; d. 1793), marks the beginning of popular Nature studies. It is composed of letters to the writer's friends, written, it is believed, at the suggestion of the Hon. DAINES BARRINGTON (b. 1727; d. 1800), who was an antiquary and a naturalist as well as a lawyer.

THOMAS PENNANT (b. 1726; d. 1798) was another famous naturalist and a friend of Gilbert White; his "British Zoology" and "History of Quadrupeds" were for a long time classics of their kind, while his "Tour in Scotland" had an appreciable effect in stimulating travel in that country. The letters of HUMPHREY PRIDEAUX, Dean of Norwich (b. 1648; d. 1724), give details of old Oxford life.

Various Writers of the Period. Among the divines whose work continues to be read may be named WILLIAM WARBURTON, Bishop of Gloucester (b. 1698; d. 1779), author of a voluminous work entitled "The Divine Legation of Moses Demonstrated." Warburton was a friend of Pope, and a man who, said Dr. Johnson, "Praised me, sir, when praise was of value to me." WILLIAM PALEY (b. 1743; d. 1805) wrote lucidly on the subject of Christian evidence. His "Treatise on Natural Theology" and "View of the Evidences of Christianity" are still read, as is also his "Horæ Paulinæ," a defence of the genuineness of St. Paul's Epistles.

WILLIAM LAW (b. 1687; d. 1761), in his "Serious Call to a Devout and Holy Life," influenced men so dissimilar as Johnson, Wesley, and Keble, and it stands by the side of Jeremy Taylor's "Rule and Exercises of Holy Living" as one of the most impressive devotional treatises in the language. THOMAS REID (b. 1710; d. 1796) wrote "An Inquiry into the Human Mind on the Principles of Common Sense." He had a distinguished follower in DUGALD STEWART (b. 1753; d. 1828).

Other Groups of Scholars. JOSEPH PRIESTLEY (b. 1733; d. 1804) is best remembered as the "father of modern chemistry," the author of a "History of Electricity," and as the man who discovered oxygen, but by a blind attachment to theory failed to appreciate its significance, leaving that honour to Lavoisier. THOMAS PAINE (b. 1737; d. 1809) wrote an influential book on "The Rights of Man," in answer to Burke, and was himself very ably answered by GILBERT WAKEFIELD (b. 1756; d. 1801). The Greek scholarship of RICHARD PORSON (b. 1759; d. 1808); the still unapproached translation of the Koran by GEORGE SALE (b. 1697 (?); d. 1736), the version of "Plutarch's Lives" by J. and W. LANGHORNE (b. 1735; d. 1779, and b. 1721; d. 1772), the standard translation of Josephus's "History of the Jews," by WILLIAM WHISTON (b. 1667; d. 1752), all testify to the learning and literary activity of the eighteenth century.

An Age of Scholarship. But this list, long as it is, and irrespective of the fact that we reserve fiction for separate consideration, is far from comprehensive. We have not yet mentioned the translations from the Sanskrit of Sir WILLIAM JONES (b. 1746; d. 1794); the scholarly discourses of Sir JOSHUA REYNOLDS (b. 1723; d. 1792); the valuable "Diversions of Purley" of JOHN HORNE TOOKE, the philologist (b. 1736; d. 1812); the educational manuals of ISAAC WATTS (b. 1674; d. 1748); the colossal "Commentaries on the Laws of England" of Sir WILLIAM BLACKSTONE (b. 1723; d. 1780); the "Anecdotes" of JOSEPH SPENCE (b. 1699; d. 1768); the "Anecdotes of Samuel Johnson" by Mrs. THRALE (b. 1741; d. 1821); the "Travels" of MUNGO PARK (b. 1771; d. 1806), or the admirable Shakespearian studies of GEORGE STEEVENS (b. 1736; d. 1800), EDMUND MALONE (b. 1741; d. 1812), and JOHN DENNIS (b. 1657; d. 1734).

Early Journalism. It is of interest to remember that "The Times," first started as "The Daily Universal Register" in 1785, came out with its present title on January 1st, 1788; that the "Gentleman's Magazine" dates from 1731; and that there was a "London Magazine" in 1732, a "Monthly Review" in 1749, a "Literary Magazine" and a "Critical Review" in 1756; while, in addition to other encyclopaedias, the "Encyclopaedia Britannica" appeared for the first time in 1771, in three volumes.

A Plea for General Knowledge. We have thus arrived at the end of the eighteenth century in our study of English prose, and have thought it well to maintain up to this point our historical treatment of the subject rather than to dwell at any length on the practical side of prose study, or the examination of special branches of prose writing, though we have at least gleaned some useful knowledge by considering the different styles of the master-writers of the age. But presently we shall look more closely into the fabric of our English prose, now that we are coming into touch with the living and growing prose of our own time.

This great distinction has to be noted between the eighteenth century and our own time: that the term "a man of letters" formerly stood—even into the middle of the Victorian Age—for one who had ranged at will in all those fields of study represented in our history of eighteenth century prose-writers—philosophy, travel, history, fiction, science, religion, and so on. Unhappily, but perhaps inevitably, the nineteenth century saw a great change in the direction of "specialising," not only in the case of writers, but in that of readers. Authors now find it profitable to limit themselves to one branch of literature only; readers, with far less reason on their side, are too prone to fall into the same habit. In the eighteenth century it was accounted no discredit to a writer that he expended his energies in many different fields of thought: that he wrote histories, biographies, poems, criticisms, philosophies, stories. In our day this would be to an author's disadvantage; publishers would demand that he produce only the class of book which they could sell most rapidly. That is the author's excuse, and it is a valid one; but the reader who confines himself to only one class of reading has no excuse. The man who today would be well read should go for example or precedent to the "men of letters" of the eighteenth century, who regarded the whole varied field of literature as their hunting-ground, and were not content to linger unduly in one particular corner of it, but to range throughout its length and breadth.

J. A. HAMMERTON

EXAMINATIONS FOR THE NATIONAL CIVIL SERVICE

Postmen, Messengers, Office Keepers, and other subordinates are generally appointed, after nomination by the Head of Department concerned, after elementary test. Assistant Inspectors, Board of Education (£200 to £800), are nominated by Secretary and appointed without examination.

Appointments	Age Limits	Educational standards (and special requirements, if any)	Fees	Initial salaries or weekly earnings, and maximum ordinarily attainable	Average number of vacancies yearly	Average number of candidates for each vacancy
APPOINTMENTS BY OPEN COMPETITION						
Posts on General Staff						
Clerk, Class I.	22 to 24	High and searching	£6	£150 or £200 to £800, £1000	26	7
Intermediate Appointment ..	18 to 19½	Public school grade	£3	£100 to £450, £600, etc.	25	8
Clerk, Second Division	17 to 20	Secondary school grade	£2	£70 to £300	225	9
Assistant Clerk	19 to 21	Simple. Must have served as Boy Clerk	10s.	£45 to £150	190	3 to 4
Boy Clerk	15 to 16	Simple	5s.	15s. to 16s. weekly	800	2·5
In Particular Departments						
Officer of Customs and Excise ..	19 to 21	Moderate	£2	£80 to £300, etc.	200	7
Assis. Examiner, Patent Office ..	20 to 25	Scientific subjects	£5	£150 to £450	10	9
Clerk, Office of Woods	19 to 23	Legal. Must have been in a solicitor's office	£2	£100 to £430	Occasional	9
Apprentice, H.M. Dockyards ..	14 to 16	Simple	2s.6d.	4s. to 15s. weekly while indentured	350	3
Boy Artificer, Royal Navy ..	15 to 16	Simple	2s.6d.	3s. 0d. to 45s. 6d.	60	10
Man Writer	19 to 26	Elementary	1s.	24s. to 39s., 51s.	Numerous	—
Boy Writer	15 to 17	Elementary	1s.	9s. to 21s.	Numerous	—
Abroad						
Indian Civil Service	22 to 24	As Clerk, Class I.	£6	£300, to £1500, £2000	50	4
Eastern Cadet	22 to 24	As Clerk, Class I.	£6	£300 to £1400, etc.	25	7
Indian Police	19 to 21	Public school	£2	£240 to £840, etc.	30	5
Posts for Women						
Woman Clerk, G.P.O.	18 to 20	Secondary school	15s.	£65 to £130	40	12
" Health Commission ..	18 to 20	Secondary school	15s.	£65 to £110	—	—
Girl Clerk, G.P.O.	16 to 18	Secondary school	15s.	£42 to £48	70	10
Female Learner (London) ..	14 to 17	Elementary	4s.	7s., 14s., to £2	200	10
Female Learner (Provincial) ..	15 to 17	Elementary	4s.	5s., 13s. to £1 16s.	120	12
Female Sorter, Post Office	15 to 18	Elementary	3s.	14s. to 30s. weekly	55	14
Card Teller, Health Commission	15 to 18	Elementary	3s.	14s. to 30s. weekly	—	—
APPOINTMENTS BY NOMINATION						
Clerk and Attaché, Foreign Office	22 to 25	Languages essential	£6	£150 to £1000 etc.	8	4
Clerk, Royal Courts of Justice..	20 to 30	Simple	£6	£100 to £400, etc.	19	Qualifying exam. only
Assistant, British Museum ..	20 to 25	Science or Arts	£5	£150 to £500, etc.	4	3
Junior Inspector of Mines, etc. ..	23 to 25	Mining subjects	£6	£300 to £450, £700	3	1 to 4
Sub-Inspector of Mines, etc. ..	30 to 40	Practical Mining	12s.6d.	£150 to £260	Few	—
Inspector of Factories	21 to 30	Advanced	£3	£200 to £450, etc.	8	2 to 4
Assistant Inspector of Factories	21 to 40	Simple	12s.6d.	£110 to £200	3	10
Clerk, Prisons Service	18 to 22	Moderate	£1	£70 to £300	3	—
Junior Clerk, Post Office ..	19 to 26	Secondary school subjects. Restricted to postal servants	£1	£100 to £200, £450	10	10
Sorter, Post Office	18 to 30	Elementary	5s.	£1 to £3 2s.	320	4
Learner, Post Office (London) ..	15 to 18	Elementary	5s.	8s., 18s. to £3 2s.	58	10
Learner, Post Office (Provincial)	15 to 17	Elementary	5s.	8s., 16s. to £2 16s.	350	10
Naval Appointments						
Assistant Clerk	17 to 18	Secondary school subjects	£1 10s.	£45 to £345, etc.	20	3
Posts Abroad						
Student Interpreter, China, Japan, and Siam	21 to 24	Searching	£6	£200 to £700, £1000, etc.	5	4
Student Interpreter, Near East..	18 to 24	Foreign languages essential	£6	£200, £300 to £1000, etc	2	5
Consular Officer	27 to 30	Somewhat high	£4	£300 to £700, £1000, etc.	4	8
Posts for Women						
Female Inspector of Factories ..	25 to 40	High	£2	£200 to £300	Occasional	Qualifying exam. only
Female Typist	18 to 20	Simple, includes Typing	1s.	20s. to 28s., 35s. weekly	43	1 to 2.
Telephonist, Post Office	16 to 19	Simple	1s.	11s. to 28s.	Many	Qualifying exam. only

NOTE. Certain posts under National Insurance Commissions and in Labour Exchanges are filled either without examination or after qualifying test only. (See later chapters).

The Advantages of the National Service. Its Scope and Departments. Emoluments. Conditions of Entering.

NATIONAL SERVICE

Readers of this course will recall that at its inception the ground to be traversed was mapped out into three great provinces—the *municipal*, the *national*, and the *imperial* services. Our consideration of the first of these ended with the chapters on Poor Law appointments. We now turn to that distinct and very important branch of our general subject which is comprised in the National Service. It corresponds very nearly with that division which is technically known as the home Civil Service, though we have throughout this course employed the word "civil" in a less restricted sense.

For a clear understanding of this section it is essential, before reviewing in detail each of its many grades, to consider briefly the national service as a whole, and the general conditions characterising it. We must understand something, for instance, of the average prospects it offers, the nature of the duties involved, and the provisions existing as to the sick pay and the retiring allowances of Government servants.

And it is necessary, also, to have a clear comprehension of the methods by which appointments are filled, and the requirements in respect of education, age, and health. The prevalent system of open competitive examinations, in particular, is undoubtedly of supreme importance to prospective candidates.

We may define the national service in a phrase as the sum total of all non-fighting posts—except in India and the Colonies—which are held directly under the State and remunerated from public funds. This definition will be seen to exclude municipal servants, as their offices are held under local authorities of various kinds; but it is wide enough to embrace all other public servants of every degree. The Secretaries of State and their youngest messenger lads, our representative at Berlin or The Hague, and the modest Customs officer—all these, with every Government official of intermediate grade, are equally members of the national service.

This great army of State servants numbers between 60,000 and 70,000 of all ranks, and is entrusted with the execution of all civil affairs which are of national interest as distinguished from merely local concerns. The importance and varied nature of the duties thus performed cannot readily be estimated. With the giant work of the postal and telegraph services and of our preventive departments we all are more or less familiar; but few of us realise, probably, how much labour is involved in such functions as our prison system and courts of law, or the civil direction of the Army and Navy. To these we must add the great and grave departments of State, controlled for the most part by parliamentary secretaries, which are concerned either with the administration of internal affairs or with the problems of international relations.

In the former category we may place the Home Department and the Treasury, and in the latter the Foreign Office, Colonial Office, and that of the Secretary of State for India. In the course on the municipal service we saw that two further State departments—those of the Local Government Board and the Board of Education—exercise a central and salutary control over the actions of local authorities. Other special functions are exercised by the Board of Trade, the Patent Office, Royal Mint, and a host of offices, great and small, with whose very names the general public is unfamiliar, but whose duties, nevertheless, are of national importance. And, save for certain technical posts in the Admiralty and War Office which are reserved for members of the combatant services, every Government office is staffed entirely by officials of the national service.

In a few exceptional instances—as in the metropolitan police courts, whose officers are paid partly out of the police rate—the salaries of Government servants are derived in part from local funds, but in the great majority of cases the sources of income are wholly national. The cost

of each department, including salaries, is estimated annually in advance, and the total amounts thus calculated are submitted to the House of Commons every year and appropriated out of the nation's revenues by a parliamentary Vote on Account.

The national differs from the municipal section in several material respects. In the first place, as befits a Government institution, it is marked by a completeness and uniformity of system almost entirely wanting in the municipal world. Instead of conditions altering in greater or less degree with every change of district, the State affords its employees of each grade, throughout the country, clearly defined and practically unvarying terms of service, including rates of pay, amount and frequency of increment, and so forth. This is not entirely an advantage. Local bodies, in exceptional cases, may mark their sense of official zeal and devotion by a liberality unknown under the rigid rules of Government service. On the whole, however, a fixed and adequate scale of pay is preferable to dependence on the uncertain views of a council or board of guardians.

This uniformity of method extends also to the conditions under which the Government service may be entered and left. For admission to each of the main grades of appointment certain regulations are framed which are binding on all candidates alike, and every permanent official is subject to the same provisions as to pensions and gratuities on retirement.

A Clerical Service. A further distinction may be based on the nature of the duties in this service. The municipal section, as we have seen, comprises engineers, inspectors, chemists, police officers, firemen, nurses, and a great many others whose functions are practical and executive rather than clerical. The national branch, as viewed from the candidates' standpoint, is in the main an assemblage of clerks of various grades. There are many exceptions, it is true, notably in the Excise and Customs and Prisons departments, the inspection of mines and factories, and certain technical posts in the non-combatant staff of the Royal Navy. But, speaking generally, the work of the national service is clerical throughout.

The distinction is worth considering. It is evident that such a service, as compared with one which is largely executive, will include fewer posts for which some degree of education is not imperative. On the other hand, it affords less scope for the skilled expert and the able administrator. A clerk, however capable he may be, can hardly expect to find in his calling the same opportunities for personal distinction and rapid advancement as may await a clever analyst or architect, or a trained engineer who is willing to incur the grave responsibilities involved in carrying out great public works.

Such considerations lead us to expect in the national service precisely the features which, in fact, it displays. These are moderate but progressive salaries, promotion usually dependent on steady service, light and regular duties, and a small proportion of distinctly subordinate posts.

Lot of the Government Clerk. To a man of reasonable ambitions, who is repelled by the uncertainties and stress of commercial life, the national service, with its assured income and liberal leisure, offers many attractions. The Government clerk enjoys, indeed, a degree of consideration and dignity but rarely attained by his colleague in commerce. He is generally housed in a spacious and comfortably appointed building, as befits a servant of the State. The Foreign Office, Home Office, and other great departments in the West End of London are among the finest structures in that region of fine buildings. During the seven hours which constitute the average official day, work proceeds at an unhurried and equable pace, with due regard to the sanctity of the luncheon interval. The character of that work naturally varies with the various offices. Usually it includes correspondence or bookkeeping, indexing and docketing documents, compiling statistics, preparing reports, and similar clerkly duties. In the higher ranks the work, while of the same general character, is more responsible, and involves the supervision and control of the subordinate staff.

Such are the conditions normally prevailing in the average Government office. Certain busy, important departments, however, are disagreeable exceptions to the rule. The General Post Office, throughout all its branches, is a notorious instance in point. It employs an enormous staff of clerks and other workers on duties that are generally monotonous, uninteresting, and performed at high pressure. The outdoor officers of the Inland Revenue and Customs, again, are required to work under irksome conditions of exposure and irregular hours.

Vacation and Sick Leave. In respect of leave and sick leave the State is unquestionably a liberal employer. Higher class officials are entitled to six weeks' holiday yearly, which is extended after ten years' service to eight weeks. For officers of intermediate rank the annual leave varies between three weeks and a month, and only the distinctly subordinate grades are restricted to shorter terms of from ten to eighteen days. The provisions as to sick leave are as follow. Members of the permanent staff receive full pay while absent on account of ill health, until they have been away for six months in any one year. If still unfit for duty, they may then be placed on half-pay for another six months. At the end of this latter term their case is specially considered, and they are usually either granted further leave without pay or called upon to resign. Such considerate treatment is rare indeed outside the Government service. How beneficent the system proves in practice was illustrated by the case of a friend of the writer's, who, after a few years in a State department, developed somewhat serious lung trouble. Dependent as he was upon his salary, he might have fared disastrously in other employment. But the authorities promptly granted him six months' absence on full pay. He was thus able to make a voyage round the world, and returned quite restored to health.

Remuneration. The national service comprises appointments of a great many grades. A special feature of this chapter is a "conspectus," or general table, showing the range of salary and other particulars in respect of each rank. From this table it will be seen that these posts may be grouped approximately into four broad divisions.

Of these the first includes the highest clerical and administrative offices, relatively few in number and keenly contested. Starting at £150 or £200 a year, they rise rapidly to £800, £1000, £1200, or higher. In the second flight are the upper clerks, accountants, and other specially responsible officers, whose salaries begin at £100 or £120, and reach £500 to £750. The third class comprises the mass of ordinary clerical positions, with initial salaries varying from £70 to £100, and advancing by moderate increments to £350 or £400. Last in rank we must place the Post Office telegraphists and sorters, inferior clerks, messengers, and other subordinate officers, whose prospects are bounded by a slowly attained maximum of £150 or £200.

Promotion. Prospects of promotion vary a good deal with the different offices, some of which are conspicuous for the chances they afford, while others are as notably wanting in that respect. Generally, the traditions of the Service are opposed to the speedy promotion of juniors. This vexed question was briefly discussed in our opening chapter [page 50]. As was there pointed out, the authorities, while avowedly solicitous to reward ability, in practice make advancement by seniority a rule from which they are very reluctant to depart. Rarely is a deserving junior specially promoted. He must generally wait until all the men before him on the list have been given their "step" in turn. Hence, though a great many higher posts are filled from the subordinate ranks, and the chances of eventual promotion are consequently good, advancement comes with halting feet. The natural result is a certain degree of discontent among eager, ambitious young officials whose road to promotion is blocked by a line of stolid and not over-strenuous elders. For men of the requisite ability and resolution, however, there is a more direct method of advancement than awaiting the special recommendation of a chief or the translation of every senior officer. This short cut consists in competing while in the Service for a post of higher value—a course which is facilitated by the ample leisure left at the close of the official day.

Pensions. Among the attractions of State employment is the prospect of a pension when one's term of duty is ended. The system in force is a liberal one, and is so simple in principle that it may be summarised in a few words. Members of the permanent staff who are invalided before completing ten years' service are not entitled to claim a pension, but may receive a gratuity of one month's pay for each completed year. Officers of ten years' standing and upwards, if certified unfit for further duty, are entitled to a life pension, and a lump sum in cash besides, proportionate to their position and length of service. The pension is calculated upon the scale of one-eightieth of the officer's salary for every year of service up to a maximum of 40 years. If invalided after 20 years, for example, the superannuation allowance would be $\frac{20}{80}$ths, or one fourth of the salary. After 25 years it would be $\frac{25}{80}$ths, or five-sixteenths; and after 40 years (or more), $\frac{40}{80}$ths, or half pay, which is the *maximum* proportion attainable in any event. The additional sum in cash consists of $\frac{1}{30}$th of a year's salary for every year served, up to a maximum of 45 years—the highest grant being thus $\frac{45}{30}$ths, or 1½ years' salary.

At the age of 60 retirement is optional, and at 65 it is compulsory. Thus, an officer entering when 20 years old and reaching a post with £600 a year, can claim on his sixtieth birthday a pension of £300, and £800 in cash. Five years later he would be obliged to retire; and as not more than 40 years' service counts towards a pension, his superannuation would not be increased, but the cash payment would become £900. If, however, he entered at 25, the pension payable at 60 would be only $\frac{35}{80}$ths, or £262 10s. a year, while by continuing at his post until 65 he would complete the 40 years' service requisite for the full allowance of £300. Officers serving abroad in unhealthy districts are entitled to count every two years thus spent as three years for pension purposes; and for those who are injured in the course of their duties special provision is made. By a very generous provision, the family of a Civil Servant who dies "in harness," whatever his length of service, receive a cash grant of one year's salary. Government servants are not liable, as we saw that Poor Law officers are, to any deduction from salary on account of pension.

How Vacancies are Filled. From the figures quoted as to the number of Government officials it is evident that vacancies are constantly arising. Estimating the average official term at 20 years, it follows that some 3000 appointments must be made every year to replenish the losses occasioned by resignations and deaths. For us, as candidates actual or potential, the question is just this: under what conditions are those 3000 vacancies filled?

In the bad old days of patronage, down to the middle of last century, such posts were in the gift of the Ministers of State, who appear to have bestowed them with less regard for the needs of the Service than for the wants of their importunate friends. It is from this age that the tradition dates which depicts the average civilian as an incompetent and supercilious lounger. If such a portrait be now admittedly libellous and out of date, it is wholly because the patronage system has been gradually replaced, meantime, by one which makes ability, education, and health the passports to the Service. At first nominated candidates were required merely to furnish proofs of their fitness to serve. But in 1870 a radical change was introduced, which, by attracting capable, well-trained men to the Service, has done more than anything else to promote its efficiency.

Open Competition. This sweeping reform consisted in throwing open the majority of Government appointments to the unrestricted competition of British subjects of fitting age, health, and character. The system proved instantly successful, and is in vigorous operation today. Under the direction of a special department—the Civil Service Commission—open contests are held for posts of the various grades as occasion requires, and existing vacancies are filled by appointing the candidates who take the highest places.

From the standpoint of would-be Government employees the importance of the reform thus effected can hardly be overstated. Open competition fulfils Napoleon's boast of opening a career to talent, however lacking in influential friends its possessor might be. The highest positions in the service of the State are placed within reach of any youth of the requisite ability and education, no matter how humble in origin or poor in purse. And this tendency to democratise the Service, already strongly marked, is becoming still more accentuated. Formerly, despite the absence of caste barriers in these contests, the degree of education necessary to compete successfully for the most valuable posts proved, in practice, almost prohibitive for candidates below the middle classes in position. But with the elaborate system of scholarships devised by the County Council, extending from the elementary school to the University, that disability is minimised, and the labourer's son may now meet the scion of nobility in fair and honourable rivalry for the prize of a lucrative career under the State.

Notification of Examinations. Open competitions for the various vacancies are announced from time to time in the "London Gazette" and the leading newspapers. The advertisement of the Examining Body appears in the Thursday issue of most of the London morning papers, and may usually be found below the theatrical announcements on the centre sheet. Detailed particulars of any of the examinations there named, and of the appointments to which they relate, may be obtained on application to the Secretary, Civil Service Commission, Burlington Gardens, W.

Nominations. While public competitions form the principal means by which the national service is recruited, a certain number of posts (some of which are distinctly valuable) are still reserved for the nominees of leading officials. A list of such appointments at home and abroad, and also for women, is given in the general table which precedes this chapter. The usual practice is to name several candidates to compete among themselves for each vacancy. Contests of this character are officially styled "limited competitions," and are not advertised. In some instances, nominations for superior posts are given to subordinate officers as a reward for ability and zeal. A few technical and minor positions are filled without competition, the person designated having only to pass a qualifying examination.

As appointments as valuable are to be won by open as by limited contests, it may be supposed that a nomination is of little service to the candidate. This, however, is a gravely mistaken view. In the arena of public competition the fight for success is very keen. There are sometimes ten or fifteen candidates for every vacancy, and occasionally the proportion is as high as 20 to 1. But within the select circle of the nominated, no such stress exists, and the competitors usually number from three to five for each post. Aspirants who can obtain a suitable nomination should therefore on no account neglect to secure it.

Age Limits. Each class of appointment, as we shall see hereafter, has its own age limits as well as its special examination subjects. Except for certain subordinate work in the Post Office, the earliest age at which a permanent footing can be gained is 17, and there are few posts for which a candidate can compete after passing his 25th birthday. By a valuable provision, however, persons who have served in the Army or Navy, or as Territorials on military duty, may deduct from their actual age any time so spent. And under certain restrictions a similar allowance not exceeding five years may be claimed by members of the national service itself when competing for higher posts.

Medical Examination of Successful Candidates. After passing the educational test, every candidate is required to pass a medical examination before appointment. As is imperative in a service making such liberal provision in case of illness, this is a fairly severe test, and is particularly stringent in the case of foreign service. In the Customs and Excise good eyesight is insisted upon, but for other departments a moderate degree of short sight is not regarded as a ground for disqualification.

The Civil Service Commissioners, it may be noted, mention the following as among the commonest causes of rejection on medical grounds: poor physique, delicacy of constitution, diseases of the heart, lungs, eye, and ear, paralysis, epilepsy, nervous complaints, and diseases of the liver and kidneys, especially persistent *albuminuria*.

No aspirant who is dubious of his health can afford to disregard this question. The Commission absolutely declines to sanction an official examination of the health of any save successful candidates. On the other hand, rejection on medical grounds at the eleventh hour is a cruel possibility in such a case. Any competitor having reason to fear such a contingency would therefore do well to apply to the Secretary of the Civil Service Commissioners for their "Memorandum respecting Medical Examinations," which is explicit enough to enable any competent doctor to pronounce on the candidate's ability to pass the medical test.

Fees. The examination charges made to competitors vary from 1s. up to £6, according to the salary ordinarily obtainable in the appointment sought. A £100 maximum, for example, involves a fee of 7s. 6d.; for £200 it is 12s. 6d.; and for posts rising severally to £300, £350, and £450, the corresponding fees are £1, £2, and £4.

ERNEST A. CARR

The Problem of the Transmission of Acquired Characters. The Oneness of Life. Instinct in the Animal World.

THE VITAL IMPULSE

We have seen that Lamarck attributed such "progressive variations" as the long neck of a giraffe, or the wings of a bird, to *effort* and wishful trial on the part of successive generations of those animals. It is beyond question that effort, use, or practice will develop, in any individual, certain characteristics which he would not otherwise have displayed, and Lamarck believed that such characteristics might be inherited. On the other hand, no one would be so foolish as to suppose that effort and practice are limitless in their power, even in the individual, so that a man, by taking thought, could add a cubit to his stature.

Now, it is obvious that, however much we may incline to credit Lamarck in this respect, his theory does not account at all for progressive variation in, for instance, plants, where ideas of effort and will seem entirely inapplicable. Therefore, it is certain that we must seek some deeper and wider explanation than Lamarck's, in its original form, for what the American naturalist Cope, in a searching phrase, has called "the origin of the fittest." Let us see how the development of our ideas now stands.

Lamarck's Increasing Following. It is an entire error to assume, with most writers in this country, that Lamarck has now no followers. On the contrary, there is a large and steadily growing school of biologists who follow that great pioneer. As they are bound to modify his teaching in many respects, they are generally known as neo-Lamarckians; but while neo-Darwinism directly contradicts some of the most fundamental teaching of Darwin, neo-Lamarckism is much more entitled to its name, and here it cannot be dismissed as a surviving but moribund superstition.

In France, the great school of biologists, experimental and theoretical, are neo-Lamarckians almost to a man. In the United States and in Germany there are many neo-Lamarckians also, and there are many more in this country than the lay student might suppose. The arguments of one distinguished neo-Lamarckian in this country, Professor Cunningham, fall into place here, and must be carefully noted.

Hereditary Transmission of Acquired Characters. In the last chapter we saw that we cannot accept Darwin's theory of "pangenesis," by which he sought to explain the so-called transmission of acquired characters, relied upon by Lamarck in his attempt to account for organic evolution. Sir Francis Galton, in particular, Charles Darwin's cousin, made important experiments which directly negatived the theory of pangenesis, and our knowledge of the origin of germ-cells in each individual, which we owe above all to Weismann, shows that pangenesis is not the mode of their formation. Hereupon the opponents of Lamarck, the neo-Darwinians, have argued that the Lamarckian theory was not only disproved, but proved to be *inconceivable*. There is no imaginable way, they say, in which the germ-cells could be affected by the body so that changes in them might be induced in correspondence with changes in it.

The argument is a bad one, in any case. Many things happen which we can clearly demonstrate, but of which no explanation is conceivable. The question is one of scientific evidence, as has been repeatedly pointed out to these unscientific dogmatists, but never more forcibly than, in recent years, by Professor Bergson. Here are his notable words: "It is well known how Weismann was led, by his hypothesis of the continuity of the germ-plasm, to regard the germ-cells—ova and spermatozoa—as almost independent of the somatic [body] cells. Starting from this, it has been claimed, and is still claimed by many, that the hereditary transmission of an acquired character is inconceivable. But if, perchance, experiment should show that acquired characters are transmissible, it would prove thereby that the germ-plasm is not so independent of the somatic envelope as has been contended, and the transmissibility of acquired characters would become *ipso facto* conceivable; which amounts to saying that conceivability and inconceivability have nothing to do with the case, and that experiment alone must settle the matter."

Professor Cunningham's Theory. Now, Professor J. T. Cunningham has lately advanced considerations which show that the so-called "transmission of acquired characters" is perfectly and simply conceivable in some cases. We now know that almost all, if not all, parts of the body produce special substances, or "internal secretions," of their own, and early in this course we saw how these internal secretions, of the nature of ferments, travel as what Professor Starling calls "hormones," to summon and excite the activity of the cells in other parts of the body, for some vital purpose. The immense enlightenment which Starling's work has afforded, as to the action of parts of the body upon each other, may well apply to the action of all or any part of the body *upon the germ-cells*. This is Professor J. T. Cunningham's theory, and the reader will note with interest how closely it furnishes a parallel to Darwin's "pangenesis."

Only, whereas Darwin supposed that the germ-cells might be actually made by material contributions, or "gemmules," from all parts of the body, Professor Cunningham, knowing that that is not so, points to the principle of internal secretions, and shows how they might, in effect, produce just the results which Darwin sought to explain by his "gemmules." Evidently, if a

muscle be brought into powerful and repeated action, it will produce more than otherwise of its internal secretion, and this might quite conceivably—indeed, probably—have specific action upon those elements in the germ-plasm which were destined, in the future, to give rise to muscular tissue. Similarly, disease, followed by atrophy, of a parental organ would mean that the corresponding factors in the germ-cells did not receive the stimulus which would have been furnished to them by the internal secretion of that organ, if the parent had chosen to use it, and the corresponding organ in the offspring might thus be atrophied, too.

A Problem yet to be solved. Much work and thought will yet need to be expended upon this remarkable and highly suggestive theory of Professor J. T. Cunningham. Meanwhile, it suffices to dispose of the argument that acquired characters cannot be transmitted because such transmission is inconceivable. The French experimenter Charrin has apparently shown that certain injuries affecting parents may be registered, so to say, in the germ-cells, by means of specific chemical agents, transferred by the blood-stream from the seat of injury to the germ-cells, and it is evident that this is in close correspondence with Professor Cunningham's theory. Meanwhile, we leave this question, and return to our consideration of the difficulty that will and effort *cannot* account for progressive evolution in, for instance, plants.

The Basis of Life. Can we today meet the requirement laid down in an early paragraph of this chapter, and re-state Lamarck's idea so broadly as to cover all forms of life, and not merely those which display will and effort *in an obvious form?*

The answer is that, thanks to Bergson, we can, and here we reach almost the most famous and profound conception of this great thinker. This is his theory of the *élan vital*, or vital impulse, which underlies and explains the phenomena of living things. We have here purposely led up to the *élan vital* by way of neo-Lamarckism because, as Bergson himself points out, this is the only theory of organic evolution which can admit "an internal and psychological principle of development." Only this theory, which was, in part, at least, accepted and elaborated by Spencer and Darwin and Haeckel, recognises the profound truth that life and its functions come first, and structure comes second, as their instrument and their creature.

Convergent Evolution. Neo-Lamarckism, also, is the only theory which will account for what we are now learning to call "convergent evolution," as in the astonishing but far from solitary case of the eye of the man and the scollop. In that, and in many other cases, Life has creatively evolved, for its need of seeing, an eye which is an immensely complex and efficient organ; and has done so independently, along two widely diverse and independent lines, yet with such a result that, so far as the eye of the two species in question is concerned, the two lines have converged towards the construction of what is, in all essentials, the same eye in each case. It is quite conceivable, as Lamarck would have argued, that the same *effort* to turn the same circumstances to good account might have the same result, especially if the problem put by the circumstances (the nature of light, the laws of optics, and so forth) is such as to admit of only one complete solution. But if we are to apply this principle in general, we must read the word *effort* in a wider and deeper sense, as meaning something *inherent in the very nature of life*, and lying far deeper than the conscious, or even sub-conscious, will of such creatures as display conscious volition at all.

The Vital Impulse. "We must no longer speak," says Bergson, "of *life in general* as an abstraction, or as a mere heading under which all living beings are inscribed. At a certain moment, in certain points of space, a visible current has taken rise; this current of life, traversing the bodies it has organised, one after another, passing from generation to generation, has become divided among species, and distributed among individuals, without losing anything of its force, rather intensifying in proportion to its advance." Regarded from the point of view of what Weismann has taught us about the germ-plasm, "Life is like a current passing from germ to germ through the medium of a developed organism. It is as if the organism itself were only an excrescence, a bud caused to sprout by the former germ endeavouring to continue itself in a new germ. The essential thing is the continuous progression indefinitely pursued, an invisible movement, on which each visible organism rides during the short interval of time given it to live."

It is this original impetus of life, this *élan vital*, which underlies and moves all the various lines of evolution among which it gets divided. And in this *élan vital*, which is the Mind in all Life, can we alone find the fundamental cause of progressive variations. This creative mind is at the heart of organic evolution.

Bergson's Vision of Life. Thus we obtain the vision of Life as a spiritual or psychological reality, demonstrating itself in and using what we call "matter." In the mighty passage which concludes Bergson's epoch-making chapter on "The Meaning of Evolution," he rises to a the level of inspired poetry, thus inadequately translated: "All organised beings, from the humblest to the highest, from the first origins of life to the time in which we are, and in all places as in all times, do but evidence a single and indivisible impulse. All the living hold together, and all yield to the same tremendous push. The animal takes its stand upon the plant, man bestrides animality, and the whole of humanity, in space and in time, is one immense army galloping beside and before and behind each of us in an overwhelming charge, able to beat down every resistance and clear the most formidable obstacles, perhaps even death."

Shelley's Conception. This great conception of Bergson's has been closely anticipated, in principle, by certain famous phrases of

Shelley, in "Adonais," his elegiac poem upon Keats. Here are the two passages in question:

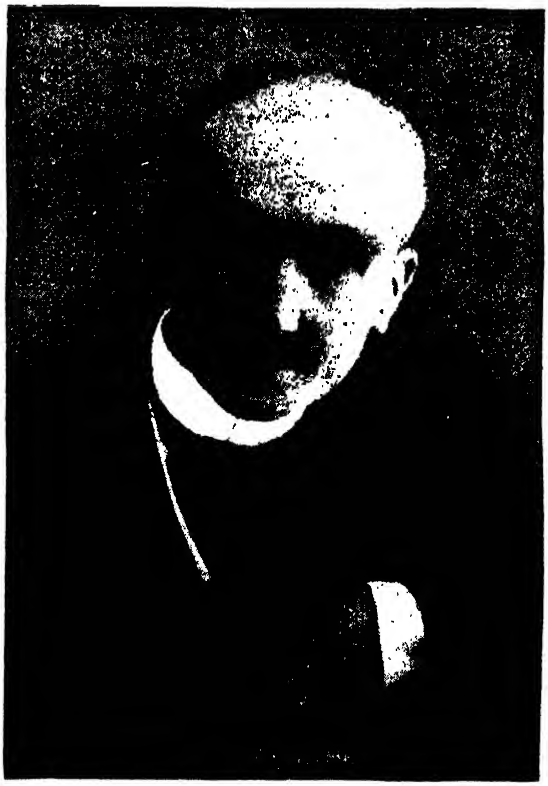
"Through wood and stream and field and hill
and ocean
A quickening life from the Earth's heart has
burst,"

and, again

"The One Spirit's plastic stress
Sweeps through the dull, dense world, compelling
there
All new successions to the forms they wear."

This second passage is extraordinary in its profound and yet precise statement. It would be impossible, in so few words, or in many, to restate the meaning and the application of the "élan vital" so perfectly as Shelley did, almost a century before the "Creative Evolution" was written. For Bergson and modern vitalism, as for Shelley, Life is Mind, and living beings are the expression of the One Spirit which, with its stress, or *élan*, is plastic—that is to say, creative, sweeping through matter, like a visible current, and compelling there the organisation of successive forms of organic evolution.

All Life is One. "Life," as Bergson says, repeating in other words the very phrase of Shelley's above quoted, "is, more than anything else, a tendency to act on inert matter." For Shelley and Lamarck, as for the later thinker, life is spirit, making and moving the body. The want, the desire, the thrust of life, thus shows itself not merely in the structure of creatures that have conscious wills—as later in the inventions of man—but also in *all* living forms, for all have in them and under them this *élan vital*, of which our consciousness and will are only the most intense and recent expressions. This *élan vital*, this current of life, takes many forms, and is ever compelling "new successions to the forms they wear." In our survey of the living world, we have already noted that life has evolved two great forms, vegetable and animal. These are no longer to be thought of as opposites, or solely as competitors for existence. They are various but complementary forms which the *élan vital* has taken. Our study of their chemistry in this course has already shown us how interdependent they are, and may suggest how necessary it is to be careful in accepting the neo-Darwinian idea of the whole living world as a vast arena of life-and-death struggle, where all creatures fight for themselves against all others. Seen by a deeper philosophy, all are part of the One Spirit; and chemical experiment upon respiration, the action of chlorophyll, and so forth prove that, though living species do also struggle among one another, they are certainly interdependent in the profoundest sense. All Life is indeed One, when deeply enough viewed.


HENRI BERGSON
From a photograph by Gerschel, Paris

The Three Lines of Life. Already we have seen how, along the line of the vegetable world, the *élan vital* has, so to say, specialised in and towards the perfecting of the use of sunlight by means of chlorophyll, and how, with this specialisation, as ever, there has been some loss or neglect or sacrifice of development along other lines. "Vegetable torpor" has been the price paid for the power and marvels of vegetable chemistry; but vegetable chemistry has made possible the evolution of something very different from torpor in the animal world, which it feeds.

It has already been noted, in a preceding chapter, that the *élan vital* has taken not two but really three great lines of creative evolution. For if, now leaving the vegetable kingdom on one side, we look at the animal kingdom as a whole, we may see two notably different aspects of vital function at work, and working themselves out along two notably different lines. We call them respectively *instinct* and *intelligence*, and the immensely significant fact is that these two things have clearly worked, or are clearly working, along and in two extremely diverse forms of bodily structure. Already we have seen that animals may be divided—for Life, indeed, has divided itself in them—into two great groups. Of these two, the invertebrates are unquestionably the older, and the vertebrates, or backboned animals, are undoubtedly descended from some kind of invertebrates, as yet undetermined.

But, as we have lately learnt, this does not mean that vertebrates are a direct prolongation

of the invertebrates, and that Life has nothing more to say in the invertebrates themselves. That is the wholly false idea of evolution which all students have now abandoned. While we admit that the vertebrates have evolved from the invertebrates, we must nevertheless independently and impartially study both these forms of life, regarding each as an expression of the *élan vital*, the "One Spirit's plastic stress," and being quite prepared to find in invertebrate evolution wonderful and admirable vital powers and creations, which in some respects cannot be rivalled among the vertebrates, perhaps including even ourselves.

Man's Sacrifice in Evolution. So far as intelligence is concerned, of course, man, more than any other creature, has infinite possibilities in front of him. Nevertheless, there are certain original powers and attributes of life which man has had to sacrifice, along the line of his evolution, just as the vegetable kingdom has had to sacrifice the awakening of mind within it in order to specialise in chemistry. Man, as the representative and consummate vertebrate, with his *intelligence*, has partly sacrificed *instinct*, which is another and a different thing, and which has revealed itself astoundingly among the invertebrates.

This view of Life, as expressing itself along the three great lines of vegetable torpor, invertebrate instinct, and vertebrate intelligence, does not mean that no instinct is to be found among intelligent beings, nor any psychical facts among vegetables. Most emphatically, as an essential part of his teaching, Bergson insists that something of all these original attributes of Life is to be found in all living things. It is, indeed, one of the most important advances of modern biology to have found, for instance, powers of synthetic chemistry analagous to the chlorophyllian function of plants in the animal body, and to have found powers of quasi-intelligent adaptation in the vegetable kingdom. It is as essential to recognise and study these facts as to notice how markedly the vital *tendency* is differentiated along these three lines. For, unless we make a special study of each of these tendencies, our view of Life as a whole will certainly be imperfect and partial.

Instinct Defined. The careful student will now be feeling ready for definitions. Never is exact and proper definition more needed than for the word "instinct," perhaps the most constantly abused word in our language. Bergson uses the word in a strictly limited sense, based upon the principle that, from the very nature of instinct, we should study it in its purest, most perfected, and latest form. And for this, beyond question, we must go to the invertebrates; among the invertebrates to the insects; among the insects to those which are called arthropods; among the arthropods to those which are known as the hymenoptera; and among the hymenoptera to those which are distinguished as social. Purposely, this has been written out in extended form, so as to show the principle of inquiry. At each stage we pass along the main line of evolution of invertebrates, and at each stage we find an intenser and more important development of instinct than ever. Just as surely as progress among the vertebrates is at present consummate in man, so among the invertebrates it is consummate among the social ants, bees, and wasps.

Instinct Reigns in Insects. In all the ordinary text-books of zoology will be found a list of the great structural differences between vertebrates and invertebrates. Today we are learning to interpret structure in terms of function, which makes and uses structure—a fact actually observed in individual or in racial evolution. Can we therefore state a profounder internal and psychological principle, which distinguishes vertebrates and invertebrates? Thanks to Bergson we can; we see intelligence as the internal factor, creating with its "plastic stress" the forms of vertebrate bodies, and instinct as the corresponding internal factor of invertebrates.

The Relation of Nerves to Instinct. Suppose we apply the idea we have now gained, and try to find order among the invertebrates by looking for *increasingly efficient instinct*. Or, if we are materialistic by habit of mind, and prefer to look for something tangible, we may follow simply the *increase of nervous tissue* in the invertebrate world. In either case, we shall reach the same conclusion, for increasing instinct and increasing nerve-matter, as its instrument, go together. The course it takes leads us up through the worms to the insects, and, keeping hold of our thread, more perfect instinct and larger nerve-centres, we surely reach the social ants, bees, and wasps. They stand as the acme of Life along the line of instinct, quite as clearly and easily topmost as man is at the growing-point of the line of intelligence.

We are ridding ourselves, the reader will observe, of the idea of organic evolution as linear. The vertebrates have not sprung from the social insects. However they evolved from the invertebrates, as they certainly did, the point of departure was far below the level of the social or any other insects. And Life is going on along their line as well as along ours. The directions and possibilities of Life are not finite, not predetermined. Hence, as Bergson says, "the unforeseeable variety of forms which Life, in evolving, sows along its path."

The New View of Creation. This is something greater, diviner than the mere carrying out of a plan, laid down by some remote Creator, outside his world. Creative Mind is *in* Life, and none can set limits to it. Here are our master's own mighty words:

"Nature is more and better than a plan in course of realisation. A plan is a term assigned to a labour; it closes the future whose form it indicates. Before the evolution of life, on the contrary, the portals of the future remain wide open. It is a creation that goes on for ever in virtue of an initial movement. This movement constitutes the unity of the organised world—a prolific unity, of an infinite richness, superior to any that the intellect could dream of, for the intellect is only one of its aspects or products."

C. W. SALEEBY

The Traveller must be a Salesman. Qualifications and Equipment. Samples Essential to Success. Don'ts for Travellers.

THE SUCCESSFUL SALESMAN

A GREAT business may very appropriately be likened to a widespread empire. In the empire there is the capital, or seat of government, where plans are formulated and schemes thought out, but these would be useless without the proconsuls and agents in all the outlying provinces to give practical effect to what is planned at headquarters. So in a great business there is the central office with the well-equipped factory, where schemes and developments are thought out, and various goods or commodities are prepared; but if these are to be of value, there is need of loyal and intelligent and enthusiastic agents all over the country, and possibly all over the world, to put the schemes into effect and to place the goods on sale.

Necessity of Successful Salesmen. Now, what the pro-consul or ambassador is in an empire of wide-world scope and importance, the traveller is in a great business; and it is well for him to recognise his importance, so long as he does not over-estimate himself personally, and begin to feel that his business would collapse without him. There may, here and there, be a man in some particular sphere who is really indispensable, which means that if he dies, or, rather, when he dies, his party or cause or business will collapse or, at any rate, gradually decline.

Such men, however, must be very few and far between; and although in great businesses there are men in the different departments who have done much to build up the organisation, yet when from any cause such men are removed, it is astonishing how soon they are forgotten, and how well the business goes on without them. It is a good axiom, therefore, for every man to remember that he, at any rate, is not indispensable to his employers, or to the business in which he may be engaged. If men only remembered and realised this, there would be far fewer promising careers cut short, and far more notable successes achieved.

Importance of the Traveller. At the same time, a business man who means to get to the top of his particular department must not think lightly of his own importance. If he is worth anything at all he must be important, and it should be his aim to do better than anyone else engaged in similar work. This is particularly the case with the commercial traveller. He is an ambassador of commerce, he represents his house; and the public estimate of its goods, and the question as to whether they shall be in great demand or not, depends very largely upon the way in which he represents the firm. The house is first of all known through its travellers. Later on it may come to be known and respected because of the high quality and reliability of its goods, and because of its business integrity, but at the outset it is judged by its representative.

Travellers should be Salesmen. The old names of traveller and representative, given to the men who went about calling upon the trade and taking orders for the manufactures of their firm, are everywhere being given up for that of salesman. Twenty years ago, in this country, at any rate, the word salesman was applied almost exclusively to the man behind the counter, and the word conjured up the vision of an assistant in a provision shop or general store with a white apron and shirt-sleeves. To apply such a term to a commercial traveller would have been regarded as a positive insult. But we have learnt better from our American cousins, who invariably use the word salesman when they are referring to the travellers or representatives of a business house. The term salesman is now regarded as a compliment by all really good travellers, for in the use of the word is implied the fact that a man does not merely travel about and represent his house—anybody could do that—but he sells the goods, which is the very reason for his existence. And the more truly a man can be described as a salesman, the more successful in life is he to be regarded.

Qualifications of a Salesman. Every man cannot make a successful salesman. A certain amount of natural ability and qualification is necessary. Just as a man who is naturally a stutterer could never hope to become a successful preacher or a popular orator, so some men have natural disadvantages—undue self-consciousness, for instance—which debar them from attaining much success as salesmen. But it must not be thought that any mere natural gifts will ensure success. A preacher or orator needs more equipment than a glib tongue, and the salesman who has all the natural gifts and qualifitions necessary will have to think hard and work hard to attain the success he desires.

What, then, are the principal qualifications for a successful salesman? He must have tact, a certain readiness of speech, a more or less effective presence, a knowledge of men, and an ability to read character quickly either from the face or from the first few sentences of a conversation, good powers of observation, a sound education, and a fair all-round knowledge of the world of today as revealed in the newspaper and current literature; and, further, he must show his enthusiasm for the goods he carries and his knowledge of them, and must be known for his integrity. Misrepresentation is of no use in salesmanship today, and the man whose word can be absolutely relied upon is the man who will in the long run win as a salesman. Above all,

he must be an optimist. It goes without saying that a salesman who is going to win through must have a good deal of tact. In no department of a great business are tact and diplomacy so necessary as in what has been described as face-to-face selling. And this tact, it must be emphasised, is not merely the tact that comes as a natural instinct; it is the tact that results from the careful study of men. Anything that can be discovered about the man upon whom a traveller is going to call, his likes and dislikes, his character his hobbies, his health, and so on, are all valuable assets, and will not only give cues for conversation, but good scope for tactful handling.

The First Qualification. Tact may almost be described as the salesman's first qualification, given, of course, that his appearance is what it should be in order to create a favourable first impression. It is by the exercise of tact that he makes his first approach, and if he is able to tell in a moment whether or not the opportunity is favourable, and just how to begin the conversation, he may be pretty sure that he has in him the possibilities of a really successful salesman. Some travellers when they are kept waiting for a long time begin to show impatience by looking at their watches, tapping with their foot on the floor, walking about and sitting down alternately, or in some such way. Anything more tactless it is difficult to conceive. Even if a salesman be treated rudely, he must not lose his temper; and it is nowhere so true as in salesmanship that "a soft answer turneth away wrath." If a prospective customer is rude, the traveller must appear not to notice it; if the man gets angry, it is better not to attempt to talk to him, but rather to wish him good-day and promise to call again. Something that occurred before the traveller's visit may have greatly upset the man, and to attempt to discuss business with him would be worse than useless.

Where Tact is Needed. Many instances where tact is needed will occur to the mind. If, for instance, a shop is full of customers and the tradesman is busy, it is wise for the salesman to say that he will call again. If the day is wet, he must be careful not to stand his dripping umbrella where the water from it will do harm or make an unsightly puddle. Orders have been lost before now by overlooking a simple matter like this. A tradesman may easily be upset on a wet day, when business is probably much slacker than it would be if the day were fine. In presenting samples, the salesman must be careful not to litter them about the counter, or office, or shop; and when going into a shop that has carefully built-up shows of small packages, he must see that he does not clumsily knock anything over. Here again instances of orders being lost through carelessness are not unknown. It is very easy in a small shop for the coat-tails to sweep some small article from a stand.

How Not To Do It. Speaking of tact, much might be said of how not to do it. A salesman should not go blundering into a shop full of people, noisily drop his sample-cases on the floor with a sigh, ask the nearest assistant where the "boss" is, and when he is pointed out go up and blurt out his business, irrespective of the fact that the proprietor is addressing a customer over the counter. Such may seem an exaggerated description of how tactless a traveller can be in trying to turn a prospective purchaser into an actual buyer, but, though it may be exceptional, it is a real instance of what actually took place recently.

The appearance of the traveller counts for a good deal. He should be neatly dressed, with a leaning to smartness, though without giving an impression of foppishness. In the old days, frock-coats and top-hats were *de rigueur* for all travellers of first-class houses. Now, however, things are much freer, but a traveller should always be well dressed and well groomed.

A Saleman's Smile. Then a salesman should always look cheerful. A bright, optimistic smile counts for a great deal. It puts the other man in a good humour, and may go a long way towards inclining him to become a buyer. It has been said very aptly that "a cheerful smile is one of the most effective weapons in the armoury of a salesman. A churlish buyer is more quickly disarmed by a cheerful greeting than by any other means. A salesman should always have the face of a winner." If he turns up at a shop with a disappointed expression, suggesting that he has booked no orders so far that day, and does not expect to book one there, then he is scarcely likely to prepossess the prospective buyer in favour of himself or his goods.

At the same time, it must not be supposed that, so long as a man wears a smile and is fairly optimistic about success, he will make a good salesman. Salesmanship is much more than knowing how to smile. "Good humour and friendliness," one writer has said, "are not the main peaks of salesmanship. They are no more than the foothills. To reach the pinnacles of salesmanship a man must have great qualities of mind as well as great qualities of disposition. He must have a brain that can play chess with the public. He must be alert, receptive, masterful. He must have his profession mapped out in large lines, and he must take his job seriously, as one that requires severe mental concentration."

Opening the Conversation. So much depends upon the first opening of the conversation that it is almost essential for a salesman to be a man of some readiness of speech. He need not be glib of tongue, but he should be able to judge his man, and to open with some remark that will interest him and get his friendly attention. It is a big mistake to have formal and stereotyped ways of dealing with customers—canned salesmanship, as it is called in America. No two men are alike, and it is necessary, therefore, to tackle each man as an individual different from all others. If the salesman can find out beforehand something about his prospective purchaser he will know how to interest him. It must not be supposed, however, that some roundabout way of coming to business is necessary. The old days when a traveller spent hours with one customer, discussing with him every

subject under the sun, have passed away. Life is too strenuous for that nowadays. The salesman has got to get round his territory, and cannot afford to waste time, and in any case the tradesman will not want too much of his time occupied. Business must be treated as such, and a true salesman, who feels that he has a good proposition to put before his customers, will not feel any fear in getting to the point as quickly as possible.

The Value of Adaptibility. The salesman must be essentially an adaptable man. The customers he will call upon have various ideas of how business should be conducted, the kind of goods that are likely to sell, and so on, and the traveller must quickly adapt himself to the man he is handling at the moment. The man's methods can be gathered largely from the style of the shop, the way in which the goods are exhibited, the type of assistants he employs, and the way they handle the customers. It is, in fact, a very good thing if a traveller has something of the Sherlock Holmes in him. Quick powers of observation are valuable in enabling one to take in a situation at a glance.

Tact in Conversation. In talking with a prospective purchaser it is always wise to fall in, as far as possible, with all he says. This will put him in a good humour, and predispose him in favour of the salesman. "Never argue with a customer," was the advice of one of the most successful business men in America. "Let the customer win. You are not out to argue, but to sell, and it is a good axiom to hold that the customer is always right." A man must be approached from his own standpoint. The salesman must try to put himself in the place of the prospective purchaser, and the selling arguments he uses should not necessarily be those that appeal to himself, but those that, from his knowledge of the buyer, he knows must appeal to that individual. "Put yourself in his place," is an injunction that must never be forgotten by the salesman who is aiming at the highest success. At one time a great deal of so-called salesmanship was mere cajolery after the prospective customer had been more or less fuddled by drink. Now, however, the drinking habit is being more and more dissociated from buying and selling, and a keen customer has to be persuaded by good reasoning, and inspired by the evident faith of the salesman in his own goods.

The Best Selling Argument. The traveller must, of course, know all the points about the articles he is selling. The quality of the materials used in their manufacture, their advantages over rival commodities, the advanced scientific methods used in their production, and so on, must all be at his finger-ends, and he must be able to show the customer convincingly why it will be to his advantage to buy. If his goods are dearer than similar articles of other firms, then he must talk up the quality; if they are cheaper, then he must point out the financial advantages to the tradesman of buying from him.

The salesman cannot know too much about his goods. He must get the full story from his sales manager, but he can supplement this with outside information culled from his reading in newspapers and books. If a man is on the look-out for points that will have a bearing on his salesmanship and selling argument, it is astonishing how much he will find in his daily paper that will be of use. In fact, it is a very good thing for a salesman to keep a commonplace book in which he can stick or write anything that may be useful to him in this way.

Convincing Faith. Above all must the salesman believe in his own goods. He must show by all that he says that whatever others may say or think, he, at any rate, has unbounded faith in what he is selling. No time should be wasted in denouncing the goods of rivals. Rather should every moment available be utilised by the salesman in pointing out the virtues of his own articles. He must not talk in exaggerated terms, for misrepresentation, though it may secure a first order, will never bring repeats, and it is the repeat orders that really count in salesmanship. Faith is remarkably infectious, and if a possible purchaser sees that the salesman has absolute faith in what he is selling he will eventually come to believe in the goods himself.

Never Over-Talk. The mistake that many travellers who are ready of speech make is that they talk too long. No man will succeed with a keen buyer on account of his much speaking; nor will the story of the unjust judge and the importunate widow hold good in salesmanship. A keen buyer can never be worried into buying, and even if he could it would be a great blunder to get orders that way, for he would not allow himself to be worried by the same salesman a second time; his resentment would be too keen when he came to himself.

A salesman must be careful, too, not to appear as if he were trying to teach the tradesman his business. Of course, this is what he has got to do, but he must do it in such a subtle and clever way that the customer does not realise what is going on. No man likes to feel that he knows less how to run his business than a stranger, and that the stranger can teach him a great deal that he does not know. This is why it is so essential that the salesman must be a good listener. He must be sympathetic to all that his customer says, so as to secure his confidence. Then he will be able to do a great deal by quiet suggestion.

It is a mistake to do too much direct pressing for orders. Rather must the buyer be led on in such a way that he will feel that the initiative has come from himself. At the same time, when a man has been moved to consider favourably the goods that are shown to him, the salesman must not rest content until he has clinched the matter. Most travellers can get inquiries, but these must result in orders, and this can only be done by persistence and hard work. As has been said, "It doesn't take a magician to turn inquiries into orders; it takes a salesman."

Meeting Difficulties and Objections. All kinds of difficulties and objections will be raised by customers, and these must be met

wisely and convincingly if success is to attend the salesman's efforts. If the selling department, with its sales manager, is thoroughly efficient and alive to its duties it will pass on to the salesmen a list of all possible objections, with model answers, which can form a basis for the traveller to work upon. But even if such material is not provided for him by his chief, the salesman should equip himself for every possible contingency by making out a list of objections that are advanced as reasons for not buying, and should then think out the very best way of meeting these difficulties. He should commit all this to writing, and revise it from time to time as he gets fuller experience, and eventually he will have a very convincing and conclusive selling argument for his goods. Naturally, the more fully he is prepared in this way the greater will be his success as he goes round among possible purchasers.

The kinds of objections that will be raised are such as these: The goods are too dear; we are already satisfied with another make or brand; we are overstocked; we do not know your goods; we find there is no public demand for your articles; you do not advertise sufficiently, and so on. Every fresh objection raised as the salesman goes around should be carefully noted in a book, and a convincing answer thought out.

Handling Men Aright. The handling of men in such a way as to win their confidence and their business is a thing that needs cultivation, and every day's experience should make one more able and efficient. "A living man," one writer points out, "is the most complex mechanism in the world. Compared to him, a locomotive is a play-toy. The slightest blunder may cause him to work badly and to break down; yet there are no printed directions attached to him. All we can do is to watch his eyes and do our best." This is true, and makes it evident that only by care and cultivation can a salesman make himself able to handle men so as to draw orders.

Samples Essential to the Salesman. No traveller can expect to do business who does not carry as full a range of samples as possible. The man who looks upon these as a nuisance, and is too gentlemanly to take round with him a good-sized bag or case, may be a pleasant talker, but he is not likely to make many new customers. People nowadays, more than was ever the case before, want to see what they are buying; and if, when a salesman is explaining the advantages of his goods and the reason why the prospective customer should buy them, he can bring out an attractive sample of the very goods in question, he will have done that which in many cases will clinch the argument and draw the order.

Method of Carrying Samples. This question of samples is receiving more attention today than ever it did. Many up-to-date businesses, particularly on the other side of the Atlantic, are going to great expense in providing really attractive and effective sample-cases for their travellers, and, where the goods are too large and heavy to be carried, it is getting more and more the custom to provide small working models. It has been found in the case of machinery, for instance, that such models, although costly, more than pay for themselves by the increased orders which result. Photographs and diagrams are, of course, good as far as they go, but these working models visualise the whole thing, and save a great deal of explanation to which busy buyers will not always listen.

Renewing Perishable Samples. It is up to the salesman himself to see that the samples he carries are clean and fresh. Where the goods are perishable and deteriorate with shaking and travelling, as in the case of many foodstuffs, then fresh samples must be obtained from time to time. To show a defective sample is worse than to show no sample at all, for an apology is needed, and the traveller who has to begin by apologising for what he is showing and selling is scarcely likely to convince a customer of the advantage of his proposition. The goods must always be shown at their best, and as nearly as possible in the way they will be offered for sale by the purchaser in his shop. Some houses whose goods are packed in bottles have small show-cases prepared which will pack in a fair-sized leather bag of the attaché type, and as these are easily removable the salesman can take out the show-case, and stand it on the customer's counter, so that he may see how the line will appear in his shop if he decides to buy. Such an arrangement is always found to pull in business.

A good selling argument in the case of a food is to get the prospective purchaser to taste the stuff, and for this purpose small individual jars or packets, with spoons and, if necessary, little plates, can be carried by the traveller. Methods vary, of course, according to the character of the articles to be sold, but to an ingenious salesman whose heart is in his work, and who gives hours of thought to devising new methods and schemes, many useful suggestions will occur of making the best of his samples. The principle applies whether the traveller is calling upon the retailer, the wholesaler, or the manufacturer.

Demonstrations to Customers. In some businesses the showing of samples is done on a very elaborate scale. An American house which sells an apparatus useful to retail shops, and has branches in almost every part of the world, gives effective demonstrations which are most carefully organised. When the salesman arrives in a town he takes a room at an hotel, arranges his apparatus on a table, with cloth of a certain shade as a background, so that the machine may be seen at its best. If necessary, he goes to the expense of having the electric lights in the room shifted, so that the rays may fall directly upon the apparatus. When everything is properly arranged he goes round to the various tradesmen in the town, and persuades them to make an appointment to come to the hotel to see his machine. If necessary, he will send a cab for them, and he is always ready to suit their convenience by seeing them in the evening after their shops are closed.

The salesmen of this company know their business thoroughly, for they are systematically trained in classes before they ever go on the road, and they know the whole story of their goods.

They have a travellers' manual given to them by their firm, which is a work of art in the clever ingenuity with which every possible point in favour of the goods is set out to the fullest advantage, and every possible objection answered in the best possible way. The men who work for this firm are fortunate in being so well provided with data—the accumulated experience of a generation of the world's finest salesmen.

But what these salesmen do, other men, working for other firms and in different lines of business, can also do. If the story of the selling scheme is not provided for them ready-made by their sales manager, they can build up their scheme and story and methods themselves. And certainly, of all methods likely to prove successful, demonstrations must take a high place. Particularly is this true in the case of domestic appliances that work, such as vacuum cleaners, apple peelers and corers, and so on. Two minutes' actual demonstration of their capabilities will prove more convincing than two hours of explanation.

Enthusiasm Needed. It is not surprising to know that all the most successful salesmen are men who have a great enthusiasm for their firms and for the goods they carry. Every salesman should believe that his own firm is the very best for the particular articles that he is selling. If he does not conscientiously think this, he may try to persuade a prospective customer, but there will be an air of unreality about his argument, and orders will not come readily. Enthusiasm is remarkably contagious; and though a salesman must not let his enthusiasm carry him away until he exaggerates and defeats his own purpose, yet he must let it be seen that he believes in his firm and its products, and takes a real pleasure in carrying the goods and offering them for sale.

Difficulties of the Salesman's Work. The salesman's work is not easy. He has a difficult and arduous task. As someone has said: "It is a salesman's business to change minds, to overcome prejudices, to break down bad customs, soften stubbornness, and let the light of reason into dark places. What is more to be desired than the ability to influence the minds of men and to change them for the mutual good of the buyer and seller?

'Emerson said: 'He is great who can alter my state of mind.' He may have been thinking of salesmen when he said it." This is perfectly true, and it must be remembered that the salesman's task is difficult because he is engaged in an argument with a man who is probably as keen as himself, and he has got to bring the man right over to his way of thinking. He cannot meet him half-way, or no sale will result. With increasing competition salesmanship grows in difficulty, and it is because of this that better and cleverer men are needed as travellers now than used to be the case.

Remuneration of Travellers. Salesmen are paid in various ways. In some businesses it is the rule to pay entirely by means of a salary, and any expenses that may be incurred have to be met out of this salary. Such an arrangement is satisfactory enough when the travelling is confined within a certain compact area, as, say, a district in London, so that fares will not come to be a very big item, and where the salary is a fairly generous one, sufficient to cover all the incidental expenses of a salesman's life. But in most cases the payment for services rendered is kept quite distinct from and independent of out-of-pocket expenses. With regard to the expenses some firms are very broad, and merely want a note each week stating in a lump sum what the expenses are. But the tendency is toward greater strictness, and in the majority of businesses more or less detailed accounts are required. A form has to be filled up, and this has spaces for railway fares, cabs, meals, incidentals, and so on. This greater strictness does not mean that good firms exercise a cheese-paring policy towards their salesmen; they always recognise where necessary adequate expenses must be incurred, but they set their faces against a policy that was at one time common on the part of salesmen of adding substantially to their incomes by piling up a bill of fictitious expenses.

Salaries and Commission. The most usual method of paying salesmen is by salary and commission. A man receives a certain moderate salary, say, £150 or £200 a year, and then he is allowed a commission of one or two per cent. on all the business he does above a certain amount in the course of the year. The salary is paid weekly or monthly, and the commission account is usually made up and paid once a quarter or half-year. Thus, supposing a traveller is given a salary of £150 a year, and one and a half per cent. on all the business he brings in above ten thousand pounds, if he does thirty thousand pounds' worth of business his income for the year will be £450. This is really the most satisfactory method of payment for both sides. The firm feel that they are paying by results, and are more ready to let the traveller make a large income than if he were getting merely a salary, and the traveller has his future within his own hands, and has got every incentive to do his utmost to increase the business he is doing.

The Prospects of Salesmen. Of course, the profession of salesman is like every other profession, in that remuneration varies greatly according to the firm, the goods carried, and the traveller himself. Some of the smaller firms, started on little capital, and dealing in goods of no particular standard, do not pay their travellers very well, and indeed they often take advantage of the competition in the profession and the misfortunes of particular men and put them on commission alone. With an article for which there is no great demand, and with which the market is already overstocked by reputable firms, this is a very poor proposition. But with good firms making a well-advertised article of recognised worth, salesmanship provides a good opening for an energetic and clever young fellow not afraid of hard work and not too thin-skinned. He may have to start with a small salary and no commission, but if he can make good it will

not be long before his firm will encourage him by raising his salary or giving him commission, or doing both. Good salesmen are not too common for a big first-class firm to run the risk of losing a man who shows promise, and after a few years a live salesman should be able to make an income of £400 or £450 a year.

Disadvantages of Salesmanship. The great disadvantage of salesmanship is that comparatively few men can hope to get beyond the figure named—£450 a year. A man is dependent entirely upon his own efforts, and as he can cover only a certain area in a single day, and can see only a certain number of men in the time available, his opportunities must necessarily be limited. There is a point beyond which the best man cannot go. On the other hand, there are compensating advantages. When a traveller has been on the road for some years he has made a number of regular friends, and orders come in more or less automatically. This makes the work easier and pleasanter than it was at first, and the only danger is that the traveller finding this may slacken off in his efforts, and thus leave opportunity for rivals to come in and get some of the business in his territory. Then, again, though there is a limit to what a man can make while he is actually on the road, if he is really keen and smart, and shows he knows the whole science of selling, he may be offered the post of sales manager in his firm, and this gives him almost infinite scope. Many of our great sales managers have been on the road, and, in fact, it is almost impossible for a man who has not travelled as a salesman to prove truly successful as a sales manager.

The Orders that Rank for Commission. A question sometimes arises in connection with the allotment of commission that causes a good deal of friction, and for this reason there should be a distinct understanding between a salesman and his firm from the outset. Are all orders received from his territory to rank for commission, or is he to be paid his percentage only on those orders that he takes directly ? Some firms insist upon the latter interpretation, but it must be said that this is scarcely fair to the salesman, who may have cultivated and worked hard at a particular prospect, and then, when the order is at last given, he may lose his hard-earned reward. This is recognised by most firms of standing, and all orders that come off the ground, whether from the traveller or direct from customers, are regarded as being the traveller's own work, and on every one he draws commission.

Motors for Travellers. For sparsely populated districts with few large centres the motor has proved a great boon, and the tendency to work a territory thoroughly has led many firms to supply their travellers in such districts with small cars. These enable the smaller trade to be called upon systematically, and though it may be considered wise to pass the orders that result through the wholesalers, yet it is generally found that the car pays. The traveller, therefore, who means to get on, even if he is not required to use a car on his present territory, should equip himself for every eventuality, and should see that he learns how to drive and the elements of handling the engine and machinery of a car. He will then be ready if his own firm offers him a car, or if another firm gives him an opportunity to take a berth more remunerative than the one he has, with the use of a small car. The motor-cycle, too, has come into use for covering scattered territories, but the objection to it is that the rider gets so dusty and dirty as to be not very presentable.

Some salesmen carry the goods of two or more firms. This is never very satisfactory, as each firm is liable to think he gives too much time and attention to the work of the others ; but, of course, it is legitimate enough, provided all the firms concerned recognise that he is travelling for others as well. It is, however, of course, quite outside legitimate work for a salesman to be working a second line of goods unknown to his principal firm, and if discovered would undoubtedly result in dismissal. This is only mentioned because the rights and wrongs of such a course are sometimes asked by young travellers. Of the commercial traveller abroad something is said in another part of the BUSINESS SECTION of this book, but, although there will be new problems to face in new countries, the principles of salesmanship are essentially the same all the world over.

Don'ts for Travellers. Someone has compiled a number of don'ts for salesmen, and these are worth repeating and remembering. Don't leave your samples at home. Don't fail to point out their good points. Don't exaggerate, but don't forget anything. Don't talk too quickly. Don't fail to get the attention of your prospective buyer. Don't fidget when talking. Don't be clumsy. Don't speak indistinctly. Don't shout. Don't forget to be a good listener. Don't tell the story of your goods as though you were reciting. Don't fail to answer all the objections advanced. Don't try to be eloquent. Don't try to be humorous. Don't forget the need for hard work. Don't fail to create interest. Don't lose your temper. Don't fail to clinch the order.

Salesmanship a Science and an Art. In conclusion, it may be well to emphasise once more the fact that salesmanship is no by-play—it is both a science and an art.

"There is a certain fund of knowledge relating to the profession of salesmanship," says a writer, "and a certain lot of principles by which the salesman, consciously or unconsciously, works which amount to a science. By the 'art of salesmanship,' we mean the actual practice of selling goods, the actual calling on customers, the displaying of samples, the presentation of telling arguments, the taking of orders, the application in business life of the knowledge comprising the science. Between the science of salesmanship and the art of selling there is much the same difference as between studying the law in a university and practising it in a court."

This is perfectly true, and it shows the necessity for the would-be successful salesman to be both scientist and artist.

CHARLES RAY

The Laws of Reflection. Fermat's Law. Reflected Images. Refraction and Dispersion. The Focus. Spherical Aberration.

PROPERTIES OF LIGHT

We now reach a more difficult inquiry, in the course of which we shall be able to elucidate some of the laws of the reflection of light, or, at any rate, to define them. We are discussing, it must be remembered, not light in itself, but the relation between light and material bodies, and though we may be able to use terms and define them, we are very far indeed from being able to explain the facts which they indicate. Take such terms as *transparent*, *translucent*, and *opaque*. We know what is meant by the first, though the ideally transparent substance has yet to be found. A lens of glass or the transparent structure at the front of the eye will let through by far the greater part of the light that falls upon it, yet some light is always thrown back or reflected, and in so far the lens is opaque.

The terms are relative. A substance which is translucent occupies an intermediate place, but obviously there is no hard and fast line to be drawn between ground glass and the glass of our window-frames. The difference between the transparent and the translucent glass is this, that the light passes through the first without being distorted or scattered, whereas the translucent body allows the light, or most of the light, to pass through so that objects seen through it have their form proportionately distorted or entirely obliterated. Bodies are visible—for instance, a pane of glass is visible—exactly in so far as they are not transparent. If the pane be perfectly transparent—to approach which condition at all it must be perfectly clear—it is necessarily invisible.

The Facts of Reflection. Having defined the terms *transparent*, *translucent*, and *opaque*, and having noted the fact that light may be absorbed by a material body, we must now inquire into the laws which determine reflection of light from those bodies which, exactly in so far as they do reflect it, are opaque.

"When a ray of light," says Professor Tait, "moving in one homogeneous medium falls upon the bounding surface of another homogeneous medium it is, in general, divided into several parts, which pursue different courses. These parts are respectively (a) *reflected*, (b) *refracted* (singly or doubly), (c) *scattered*, (d) *absorbed*."

In certain cases the whole of the light is reflected, and this we call *total reflection*. In general, the reflected portion of a ray of light is much greater when the new medium is, for instance, mercury than when it is, for instance, water or glass. But, apart from these differences, the rule is that the amount of light which is reflected in the case of any given medium is, in general, greater as the angle of incidence is greater. This, in ordinary language, means that the more obliquely the light approaches the surface, the greater is the amount of it which is reflected. In the case of surfaces which do not scatter the light, the portion of the ray which is refracted—that is to say, passed through after bending—consists of all that is not reflected. Hence it follows that the refracted portion of the ray in such cases diminishes as the angle of incidence increases.

Scattered Light. Before we go on to consider the laws of reflection from smooth surfaces, we must discuss that irregular reflection from irregular surfaces which is called the scattering of light. In such cases "the common surface of the two media becomes illuminated and behaves as if it were itself a source of light, sending rays in all directions" (Tait.) Ground glass affords a familiar instance of a substance which scatters in all directions the light that falls upon it. Thus, when a piece of ground glass is interposed between the eye and a source of light, the light is scattered at the surface of the glass, which becomes visible at every point, while the form of the source of light can no longer be detected. We have already seen that such glass would be technically described as translucent, and we now see that translucence depends upon the scattering of light.

When light falls upon an opaque body, the surface of which is not polished, it is reflected and scattered. Hence all points of the reflecting body are visible to the eye, notwithstanding what we shall afterwards come to recognise as the *laws of reflection*. The action of these laws presents a similar result when the surface of the body is polished. In such cases the surface may become quite invisible, as, for instance, when one walks into a mirror by mistake; or it may be visible only if the eye be placed at a certain point. The best description of the scattering of light and its relation to reflection is given by the late Professor Tait, one of the greatest physicists of the nineteenth century, and the coadjutor with the late Lord Kelvin in the production of the greatest of all works upon physics. We will, therefore, quote his authoritative words. He calls the paragraph which we quote the "*Visibility of non-luminous objects.*"

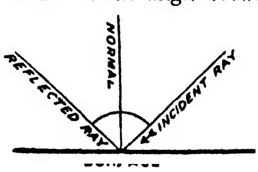
Visibility of Non-luminous Objects. "It is by scattered light that non-luminous objects are, in general, made visible. Contrast, for instance, the effects when a ray of sunlight in a dark room falls upon a piece of polished silver and when it falls on a piece of chalk. Unless there be dust and scratches on the silver you cannot see it, because no light is given from it to surrounding bodies, except in one definite direction, into which (practically) the

whole ray of sunlight is diverted. But the chalk sends light to *all* surrounding bodies from which any part of its illuminated side can be seen, and there is no special direction in which it sends a much more powerful ray than in others. It is probable that, if we could with sufficient closeness examine the surface of the chalk, we should find its behaviour to be of the nature of reflection, but reflection due to little mirrors inclined in all conceivable aspects, and at all conceivable angles, to the incident light. Thus, scattering may be looked upon as ultimately due to reflection. When the sea is perfectly calm we see in it one intolerably bright image of the sun only; but when it is continuously covered with slight ripples, the definite image is broken up, and we have a large surface of the water shining by what is virtually scattered light, though it is really made up of parts, each of which is as truly reflected as it was when the surface was flat."

The Laws of Reflection. The first law of reflection is as follows: When light is reflected from a surface, the incident rays of light, the normal to the surface, and the reflected ray of light, are all in the same plane.

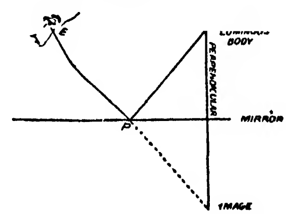
By the normal to the surface is meant a straight line drawn from the surface at the point where the light strikes it, so as to be perpendicular to the surface.

The second law of reflection states that the angle between the incident ray and the normal is the same as the angle between the reflected ray and the normal; or, in more familiar language, the angle of incidence is equal to the angle of reflection [see illustration]. These two laws may be stated in another form. The angle of incidence and the angle of reflection are equal to one another, and in one plane. Or, in yet other terms, the incident and reflected rays are in one plane with, and are equally inclined to. the perpendicular to the reflecting surface at the point of incidence.



The Law of Least Time. From the laws of the reflection of light, it follows, according to what is known as *Fermat's law*, that the path taken by a ray of light, once reflected on its course between two points, is that which can be travelled over in the least possible time. This can be stated more comprehensively thus: If a ray pass from one point to another, after any number of reflections at fixed surfaces, the length of its whole path from one point to the other is the least possible—subject to the condition that it shall *meet* each of the reflecting surfaces. "For the point in a given plane, the sum of whose distance from two given points (on the same side of the plane) is the least possible, is that to which, if lines be drawn from the points, they are in one plane with the normal or perpendicular to the given plane, and make equal angles with it." The reader should draw a diagram to illustrate this. In association with this law we must always have in our minds a further law, which can here be merely asserted, though it is implied in Fermat's law—that when a ray of light, or, indeed, any form of wave motion is refracted or bent, when passing from one medium into another in which it has a different velocity, its path from any point in one medium to any point in the other is always shorter than any other possible path. It is the shortest possible path. It might be thought, of course, that the straight line between the two points would be the shortest path. It is, of course, the shortest in length, but not the shortest in time. It is inferior in this respect to the bent path which the ray actually takes when, for instance, it passes from air to water. Less time is occupied in traversing this path, because a higher proportion of the total time is devoted to the passage of the light through that medium which permits of the most rapid propagation. In the instance we have quoted, this medium is, of course, the air.

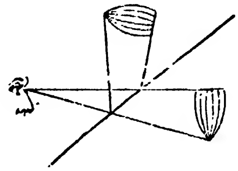
Formation of Images. When the eye perceives an image in anything—as, for instance, that of a candle—as the result of the reflection of light from a plane surface, it is always deceived, precisely as the ear is deceived by means of an echo. The information given us by the eye depends merely upon what immediately reaches it. It can tell us nothing whatever of the previous history of the light, any more than the ear can tell us the history of a sound wave prior to its reflection from an echoing surface. When we look at the image of a candle in a flat mirror we can state a simple law which enables us to locate exactly the position of that image and its relation to the objects imaged. "The image of any point in a plane mirror is found by drawing from the point a perpendicular to the mirror, and producing it till its length is doubled" [see illustration]. The drawing will make the statement of the law appear as simple as it really is. In such a case, the eye, of course, is completely deceived. It seems to see the object in the depths of the mirror, and the image thus formed is called a *virtual image*. Another way of finding it is, of course, to produce the line E—P until it reaches the point already ascertained, by drawing and doubling the perpendicular from the luminous body in the mirror. Rays proceeding from the luminous body behave, after reflection, just as if they came from the image found in the way we have described.



Real and Virtual Images. Such an image as this is called a *virtual image* because only the reflected rays appear to come from it. It is only their directions produced backwards in imagination that lead us to it. There are real images, however, which are so called because the rays of light have actually passed through them.

The case is only very slightly complicated if for the luminous point we substitute a body of some size, which, of course, consists of an infinite number of luminous points, each of these behaving according to the laws already stated.

Light coming from any point of this object and reflected in the mirror will appear to come—to vary the words we have previously used—from a point so placed that the line between it and the actual point is bisected at right angles by the mirror.



Such a virtual image is reversed, as is, of course, known to everyone who has ever looked at himself in the glass, and as may be shown very strikingly by attempting to read the reflection from a printed page in a mirror, and then by holding up to a mirror a piece of blotting-paper which has just been used. The accompanying diagram will readily show the reader why the image must be reversed.

Retinal Images. Having spoken of real and virtual images, having noted how, in certain conditions, images are inverted, let us ask ourselves the most interesting of all the questions which are concerned with sight. In due course we shall discuss the eye as an optical instrument —incomparably the most wonderful of all optical instruments, notwithstanding the remark made by Helmholtz, though quite unworthy of him, that "if it were sent him by a scientific instrument maker, he would promptly return it as grossly defective." Owing to an extremely simple fact, all the images which are formed upon the retina are inverted. The eye contains a doubly convex lens, and the consequence of the passage of the rays of light from any object through it is to cause an inverted image to fall upon the retina. This fact is quite beyond dispute. Thus, in the case we have described, where, by reflection, an inverted and virtual image reaches the eye, that inverted image is reinverted so as to form a non-inverted, or upright, image on the retina. But while we interpret an inverted image as not inverted—that is to say, while we do not see things upside down, even though the images of them in our eyes are upside down—yet in this case the re-inverted image is interpreted by us as if it were once inverted. We see a tree reflected in water as if it were upside down, and the tree itself as if it were right side up, yet in point of fact the image of the tree itself is upside down upon the retina and the image of its reflection in the water is right side up upon the retina.

How can we explain the paradox that we see everything upside down, and that, notwithstanding, we see everything right side up?

Our Eyes are in the Back of our Heads. The true explanation is that our whole conception of what constitutes the act of vision needs *revision*. We have not yet thought about it in any real sense. We are thinking of mind in terms of space. But space or extension is not a property of the mind. We have unconsciously formed a sort of notion of the mind, or thinking subject, as standing upright somewhere behind the eye and looking at the inverted images which are thrown upon the retina at the back of the eye. This, however, is quite false and ludicrous. In point of fact, it is perfectly well known that the images formed upon the retina lead to certain stimulations of the optic nerves; that these pass backward from the two eyes to certain intermediate cells near the under surface of the brain; that from these there pass new fibres, which convey the nerve impulses right through the substance of the great brain to its hindmost part, where the vision centre lies.

Everyone's veritable eyes are thus in the back of his head. Somewhere in the wonderful cells of the vision centre, which lie in the grey matter covering the occipital lobes at the extreme posterior aspect of the brain, these nerve impulses are appreciated in the form of vision. There is no one standing and looking at the inverted images upon the retina. No terms of space, up and down, right and left, are applicable to the actual act of vision. As long as the retinal images show a consistent correspondence to external reality, the perceiving subject is not deceived. It matters absolutely nothing to him whether the image of a man standing on his feet is erect or inverted, provided that he is always one or the other, so long as the man stands on his feet, and is always reversed if he stands upon his head.

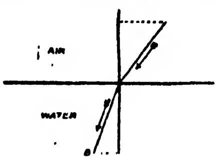
Illustrations of Refraction. The appropriateness of the word refraction, which is derived from the Latin *frango* (I break), is evident to anyone who has seen the apparent breakage of a pencil partly immersed in a tumbler of water. A still more striking instance of refraction is furnished by the familiar experiment of putting a coin in a teacup, standing so that it is just hidden from the eye by the edge of the cup, and then pouring in water. At a certain point the coin will become visible. This means that the rays of light passing from it through the water have been refracted or turned at an angle on passing from the water into the air, so that we are enabled to "see round a corner." The laws of refraction hold true whether we trace the course of light from, for instance, air to water or from water to air. In the first case, the light is bent towards the normal; in the second case it is bent from the normal. (We have seen that the normal is the perpendicular to the surface.) The facts of refraction are very much more important than those of reflection, because they enable us to make discoveries concerning the very nature of light, and because of their value in optical instruments.

The Laws of Refraction. If we state these laws in a double form, the first is identical with the similar laws of reflection. The incident ray, the refracted ray, and the normal are all in one plane.

The second part of the law of refraction is much more difficult, and is known as the *law of sines.* Professor Tait thus states the two laws in one sentence: ". . . the incident and refracted rays are in one plane with the normal to the surface and the sines of their inclinations to it are in a constant ratio." The latter part may be otherwise stated, thus: no matter the angle at which the incident light falls upon the refracting sur-

face, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is always the same—for any two given media. This remarkable fact—the law of single refraction—was discovered by Snell, a physicist of Leyden, about the year 1620.

The accompanying figure will allow the reader who is unacquainted with trigonometry to understand the meaning of this law. We have taken equal lengths of the incident ray and of the refracted ray, and from the terminal points of each—*a* and *b*—have drawn perpendiculars to the normal (the dotted lines). Given the same two media, say air and water, the ratio of the one dotted line to the other is *always the same*, no matter at what angle the incident light impinges.



Refractive Index. It is necessary to understand clearly what is meant by the *constancy* of the ratio between the two sines—or between the dotted lines drawn in the conditions of our diagram—in order to be able to understand what is called the *refractive index*. The ratio of the sine of the angle of incidence to that of the angle of refraction is always greater than 1 when the light passes from a rarer to a denser medium, as, for instance, from air to water. This is only another way of saying that, in such cases, the ray is always bent towards the normal. The converse of this statement is obviously true. It is thus possible to express very briefly the amount of refraction which is characteristic of various media, assuming that in each case the light passes into them from air. The ratio of the sines in the case of the passage from air into water is as 4 to 3, and the term refractive index is applied to this figure; in other words, the refractive index of water is 1·33. This may be compared with the refractive index of the diamond, which is about 2·4. It is this very high value of the refractive index which gives the diamond its brilliance.

A Complication. But the case is not so simple as we have hitherto described. Snell stated the law of simple refraction perfectly, but for one notable exception. He said nothing about the kind of light employed; nor could he, since he did not realise those facts concerning the nature of light which refraction itself has subsequently enabled us to discover. In describing the refractive index for any two media, or for any second medium in relation to air, it is necessary to specify that the light be homogeneous, or all of one wave length. If we employ mixed light, such as white light, its various constituents are differently refracted; thus the figures quoted above are true only for homogeneous yellow light of a given wave length. This the reader already knows, since we have quoted from Newton himself, the discoverer, the statement that "Light itself is a heterogeneous mixture of differently refrangible rays." We may make further quotations from the classical words in which Newton announced his discovery in a letter to a friend.

Newton's Experiment. "In the year 1666 I procured me a triangular glass prism, to try therewith the celebrated phenomena of colours. And in order thereto having darkened my chamber, and made a small hole in my window shuts, to let in a convenient quantity of the sun's light, I placed my prism at its entrance, that it might be thereby refracted to the opposite wall. It was at first a very pleasing divertisement to view the vivid and intense colours produced thereby; but after a while, applying myself to consider them more circumspectly, I became surprised to see them in an oblong form, which, according to the received laws of refraction, I expected should have been circular. . . . Comparing the length of this coloured spectrum with its breadth, I found it about five times greater." He then goes on to describe several modifications of the experiment which he thought might explain the result he had observed.

The Crucial Experiment. Finally, Newton tried what he calls the *experimentum crucis*, or crucial experiment, a phrase derived from a celebrated argument of Bacon's in his "Novum Organum." He says:

"I took two boards, and placed one of them close *behind the prism at the window*, so that the light might pass through a small hole, made in it for the purpose, and fall on the other board, which I placed at about 12 ft. distance, having first made a small hole in it also for some of the incident light to pass through. Then I placed another prism behind this second board, so that the light trajected through both the boards might pass through that also, and be again refracted before it arrived at the wall. This done, I took the first prism in my hand, and turned it to and fro slowly about its axis, so much as to make the several parts of the image, cast on the second board, successively pass through the hole in it, that I might observe to what places on the wall the second prism would refract them. And I saw, by the variation of those places, that the light, tending to that end of the image towards which the refraction of the first prism was made, did in the second prism suffer a refraction considerably greater than the light tending to the other end. And so the true cause of the length of that image was detected to be no other than that *light* is not similar or homogeneal, but consists of *difform rays, some of which are more refrangible than others*; so that without any difference in their incidence on the same medium, some shall be more refracted than others; and therefore that, according to their *particular degrees of refrangibility*, they were transmitted through the prism to divers parts of the opposite wall."

Total Refraction. It follows from the laws of refraction that under certain conditions light must be totally reflected from the surface, refraction being impossible. Thus, in the case of homogeneous light in air that is shining upon water, the refractive index, as we have seen, is about one-third. If, however, the angle of incidence is made extremely oblique,

THE MIRAGE—HOW LIGHT DECEIVES THE EYE

A MIRAGE AT SEA, WHERE LIGHT-RAYS FROM THE SHIP STRIKE UPON LAYERS OF DIFFERENT DENSITY IN THE UPPER AIR, AND ARE REFLECTED DOWNWARDS

A MIRAGE IN THE DESERT, WHERE A SCENE HAS THE APPEARANCE OF BEING REFLECTED IN WATER

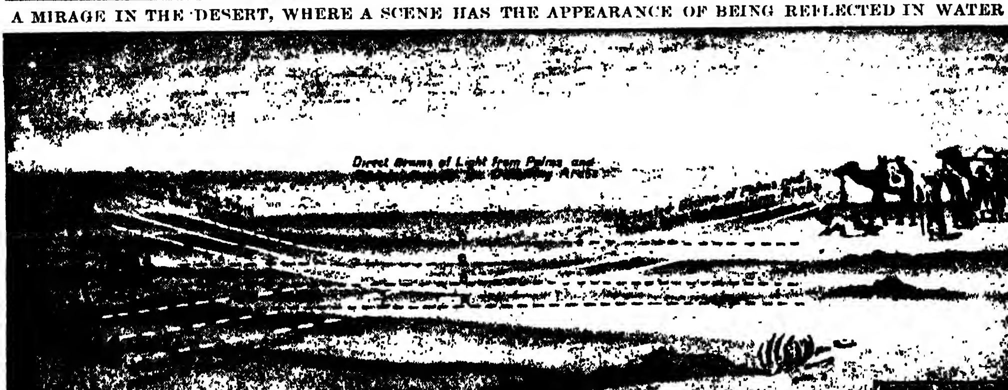
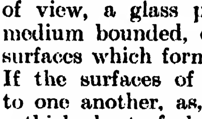


DIAGRAM EXPLAINING MIRAGE IN THE DESERT—BEAMS FROM THE PALMS BEING REFRACTED BY PASSING THROUGH THE LAYERS OF AIR A, B, C, D, WHICH ARE OF DIFFERENT DENSITIES

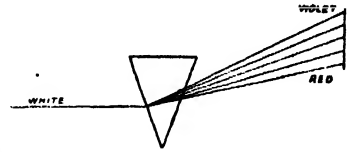
the law of sines cannot be satisfied and the light is all reflected from the surface of the water. The case is much more striking, however, if we consider the source of light to be under the water, and the light to be endeavouring to make its way into the air. We have already seen that in such a case the light is bent away from the normal. If the incidence of the light be made more and more oblique, at last the ray is totally captured ; the light cannot get out of the water at all, but is all turned back, this being known as *total internal reflection.* The limiting angle of incidence, at which all refraction becomes impossible, is known as the *critical angle.* Light cannot pass from a denser into a rarer medium when its angle of incidence exceeds the critical angle for the case in question. In the case of the diamond the critical angle is very small as compared with glass or water. Indeed, light cannot get out of a diamond except at an angle less than about 23°. If the angle be greater than this the light is totally reflected internally. Hence, the brilliance of the gem.

The Mirage. Just as the laws of refraction explain the visibility of celestial objects which may be actually below the horizon, so the critical angle and total reflection produce the *mirage*, an optical illusion by means of which we may be able to see terrestrial objects which are often really far below the horizon. This occurs where the density of closely adjacent layers of air varies greatly. In the desert, for instance, the air near the ground may sometimes be rarer than the air above it. The mirage may take many different forms, the image sometimes being inverted, sometimes erect, double or single. It occurs, of course, also at sea. The commonest form is where distant objects seem to be reflected in what looks like a lake of water in the heavens. The phenomenon is due to successive refractions through successively denser layers of air, until at last a layer is reached at the angle of total reflection. The rays of light are then returned to the eye of the observer.

The Prism. We all know what, in general, is meant by a *prism*. From the present point of view, a glass prism is simply a refracting medium bounded, or partly bounded, by plane surfaces which form an angle with one another. If the surfaces of such a medium be parallel to one another, as, for instance, in the case of a thick sheet of glass, the light passing through it is refracted, but emerges from the retractive medium in a course strictly parallel to its previous course. Thus, in looking through a sheet of glass the position of objects relatively to one another is not changed. The whole of the light passing through has been refracted, but there has been no modification of the mutual relations of the refracted rays. Very different is the case of the prism. The accompanying diagram shows a prism through which a ray of light is passing, the light being supposed to lie in the plane of the paper. We see that when the light enters the prism it is bent in the direction of its thicker part, and is again bent in this direction when it emerges.



Dispersion. But now let us suppose that we are dealing with ordinary white light. The previous quotation of Newton's words will tell us what happens. When Newton made a slit in his shutter, he found that the image of it, after passage through a prism, yielded a band of colour. Newton's experiment can easily be repeated. A mirror placed in the sunlight is used to direct a ray of light through a slit into a dark room, a prism is placed in the path of the ray, and a band of colours constituting the spectrum is thrown upon the opposite wall. The technical name for this spreading out of the constituents of white light into a many-coloured band by means of a prism is "dispersion." "The amount," says Professor Tait, "by which any part of this spectrum is shifted from the true position of the bright slit depends (other things being equal) upon the amount of the refraction. It also depends upon the angle of the prism. And, for a given angle, the length of the spectrum depends upon the difference between the refractive indices of the red and the violet rays. This is called the dispersion."



The Correction of Dispersion. If, now, we take a second prism, having the same angle as the first, and place it in the path of the spectrum, we find that it recombines or gathers together again the dispersed rays, restores the light to its original direction, and yields us the unaltered image of the slit again. This simple experiment of Newton proved once and for all that sunlight is a mixture of all sorts of colours, and that the colour we call *white* is simply the sum of all these. But Newton further concluded from the second experiment that dispersion and refraction go together, because he found that when he corrected the dispersion he also corrected the refraction. In other words, he concluded that the amount of dispersion is, in all substances, proportional to that of the refraction. If this were so, and we combined two prisms made of two different substances, having different refractive indices, and also having different angles, so that the second would exactly annul the dispersion caused by the first—then the refraction would also be annulled. Fortunately, however, as we shall see later, Newton was wrong. Many years afterwards it was discovered that "we have in certain media large refraction with comparatively small dispersion, and vice versâ, and thus that the dispersion may be got rid of while a part of the refraction remains." Previous to this discovery it had occurred to one observer that the human eye might furnish the key to the problem, for in the eye there are several media *of different kinds*, and their combination permits of re-

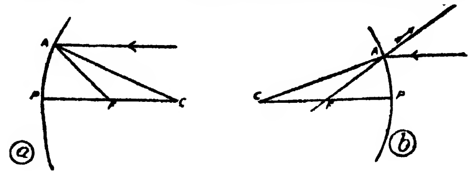
fraction with only very little dispersion. To this we shall return when we consider lenses.

A New Complexity. So much for a preliminary discussion, with the irreducible minimum of mathematics, of reflection and refraction at plane surfaces. We must now turn to the difficult questions raised by the incidence of light upon spherical surfaces.

We may begin with reflection at a spherical surface. If we take any point upon the surface of a sphere, we may conceive of a plane which is called the *tangent plane*, and which may be understood best by saying that the plane of a billiard table is the tangent plane to that point where a ball rests upon it. Now, what we have already defined as the normal in such a case must pass through the centre of the sphere. These facts are all that are necessary by way of introduction to the understanding of the behaviour of a spherical mirror. Such a mirror may, of course, have two reflecting surfaces, the one internal or concave, and the other external or convex. Speaking of such a mirror, we define as its centre, or more properly as its centre of curvature, the centre of the sphere of which the mirror forms a part. The mid-point of the reflecting surface of the mirror is called its pole, and the straight line joining the *pole* and the centre of curvature is called the *principal axis*.

The Principal Focus. By the *principal focus* we mean that point towards which the mirror reflects the rays that fall upon it directly—that is to say, in a direction parallel to its principal axis. The diagram shows the incidence of rays parallel to the principal axis. After reflection such rays all converge to the point F, the law, of course, being followed that the angle of reflection is equal to the angle of incidence. In our diagram AC will represent the normal to the tangent plane at A, and the angles on each side of it must be equal. Hence, it can be easily proved that the point F is midway between P and C—that is to say, we make the assertion that *the principal focus of a spherical mirror lies on its principal axis, half-way between its centre of curvature and its pole.* To this point all rays of light impinging directly upon the mirror are reflected.

If we turn the mirror round, so to speak, and



use its external surface so that it becomes a convex mirror, the same is true. The rays turned back from the surface of the mirror indicate the principal focus, which is again the mid-point of the principal axis of the mirror, but in this case, of course, the rays of light do not reach the focus at all, and it is thus a *virtual focus* [see diagram (*b*)].

DOUBLE REFRACTION THROUGH A PIECE OF ICELAND SPAR

Spherical Aberration. The simple statement we have made as to the principal focus is, however, not strictly true. The further away the incident rays are from the pole of the mirror the less accurately do they conform to this rule. They pass near the principal focus, but not actually through it. The nearer the principal axis the less is the deviation. The effects of this inexactitude upon the resulting image are technically known as *spherical aberration.* If, however, instead of using a spherical mirror, the section of which is an arc of a circle, we use a parabolic mirror, the section of which is a parabola, all rays whatsoever, parallel to the principal axis of the mirror, are precisely reflected through the principal focus. For astronomical purposes absolute accuracy is necessary—hence parabolic mirrors are employed for the mirrors of reflecting telescopes, and spherical aberration is avoided.

Evidently in the case of a spherical mirror any radius is equally able to act as principal axis. On this principal axis there are two points which have a reciprocal relation to one another, such that the rays from either are brought to a focus at the other; they are therefore called *conjugate foci* or focuses (Latin *jugum*, a yolk). We shall see that lenses have similar properties. C. W. SALEEBY

Limestone and Chalk. Chemical Composition. Types of Kilns. Lime Burning. Quicklime and Slaked Lime. Hydraulic Limes. Mortar.

LIME AND LIME BURNING

Chalk and Limestone. The raw material for the preparation of lime consists of a chemical substance known as calcium carbonate, which is found occurring naturally in large deposits as chalk, limestone, and in other forms.

To convert these substances into lime, they require to be strongly ignited, so that the carbon dioxide they contain may be driven off.

$$\frac{CaCO_3}{\text{Calcium carbonate}} = \frac{CaO}{\text{Quicklime}} + \frac{CO_2}{\text{Carbon dioxide}}$$

The process of preparing lime, generally known as "lime burning," is an extremely old one. Lime is the main constituent of mortar, and, as such, was used in building construction a thousand years ago or more.

To prepare pure lime some form of calcium carbonate is required, free from clay and earthy matters, and for laboratory use marble is a suitable substance; but for building purposes, where large quantities are required, marble is too compact a material and too costly.

Neither chalk nor limestone consists of pure calcium carbonate, but the natural rocks always contain small quantities of "silica" or "silicates," in the form of flint and other substances. Some account of silica and silicates will be found in the CHEMISTRY course. We may, however, state here that such substances as sand, flint, and rock crystal consist of silica, while clay is mostly made up of silicates.

Chalk Deposits. In the South of England there are two well-known chalk deposits. The upper, or white chalk is a very pure material, containing at most two or three per cent. of silicate of alumina and iron, while the grey, or lower chalk, which underlies the white chalk in the Thames estuary and the Medway district, is not so pure, and contains on an average 90 per cent. of carbonate of lime and 10 per cent. to 15 per cent. of clay substance. These clay matters are, of course, naturally incorporated with the chalk and cannot be removed. If less than 5 or 6 per cent. be present, a so-called "fat lime" is obtained, while with larger percentages of silicates the products are known as "intermediate," or "hydraulic" limes. The white chalk as quarried contains 15 to 20 per cent. of water. The other raw material, limestone, occurs in large quantities in this country. Stones which may be excellent for building purposes are not necessarily suitable for lime burning. In the neighbourhood of Buxton a very pure variety of limestone is worked, yielding an excellent quality of "fat lime."

Limestone Deposits. Great masses of mountain limestone are widely distributed over the Derbyshire district, and disruptive agencies which have been at work in producing some of the peculiar characteristics of the country have also placed at our service various beds or layers of rock.

The layers of ancient deposits have been broken up and left near the surface, so that here and there beds of limestone of various ages are found, which have been thrown up from below. Thus, in the high Peak district of Derbyshire there is a great mass of limestone at Harper Hill, near Buxton, which is held to be formed of beds, termed "the lower beds," from strata hundreds of feet below the beds of limestone surrounding it.

Lime burning is an old industry in this neighbourhood, and the experience gained in burning the different types of limestone led to a classification and selection of the most suitable for the purposes required.

The purest limestones, such as those from Harper Hill Quarries, are well adapted for chemical work, such as the manufacture of caustic soda, bleaching powder, etc. They are also suitable for fine plaster work, and as a chemical manure for putting on the land.

Limestone Analysis. We give below some analyses of these limes, made during the past year (1905), from the limestones of the Harper Hill Quarries, Buxton.

In the first place we may compare the analysis of the limestone with that of the lime obtained from it.

LIMESTONE

Silica	0·20
Oxides of Iron and Alumina .	0·30
Carbonate of Lime	99·30
Magnesia	0·20
	100·00

LIME

Moisture and Organic Matter	1·10
Silica	·25
Oxides of Iron and Alumina..	·20
Lime (CaO)	98·20
Magnesia	·25
	100·00

It must not, however, be supposed that all limestones from this district contain the very high percentage of lime shown in these analyses.

To familiarise the reader with what he may expect to find in a good lime, we give two more analyses of samples prepared from Buxton limestones.

	"A"	"B"
Silica	2·14	7·00
Oxides of Iron and Alumina	0·54	3·60
Carbon Dioxide	0·35	0·13
Moisture and Organic Matter	0·75	2·27
Lime (CaO) Pure Lime ..	95·60	86·20
Magnesia	0·62	0·80
	100·00	100·00

It will be seen that all these samples are almost free from magnesia. This is a very important consideration when the lime is used for chemical purposes or for artificial manure.

Sample "A" contains 95·6 as against 98·2 per cent of caustic lime in the first analysis quoted, while sample "B" contains only 86·2 per cent.

This latter sample belongs to the class of "intermediate" limes. If we add together the amounts of silica and oxides of iron and alumina contained in it, we shall find that they amount to over 10 per cent. of the whole.

Later on we shall go into the question of slaking of lime, but we may mention here that it is a peculiar characteristic of the purest limes of the Buxton district that when slaked they fall to a fluffy, impalpable powder which readily passes through a fine sieve, leaving practically no residue, whereas it is said that equally pure limes from other districts, although they fall to powder, leave an appreciable residue on a similar sieve.

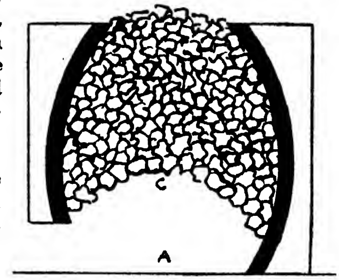
This latter class of material is more suitable for other purposes, such as the purifiers of gas works, where the gas has to pass between tiny particles of lime.

Effect of Silica on Lime. The differences in behaviour between these two classes of limes may perhaps be looked for in the manner in which the silica is contained or combined in the mass of carbonate of lime. In the Buxton lime it is probably in the form of very minute crystals diffused through, but not combined with, the lime. In other cases it is probable that a proportion of the silica is in combination as silicate. There is no doubt that the presence of any quantity of silicates, as in the form of clay, retards the slaking and renders it incomplete.

The limestones of the Lias formations [see GEOLOGY], such as are found in the Lyme Regis deposits, contain 10 to 30 per cent. of clay and a large proportion of iron. This has a curious effect upon the stone, which is blue inside and changes to a yellow-brown colour when exposed to the air. It yields a good "hydraulic" lime.

"Carboniferous" limestones are also worked, and sometimes yield a high grade of lime. Many limestones, often termed magnesian limestones, contain a varying proportion of carbonate of magnesia in conjunction with carbonate of lime. Such rocks are unsuitable for our purpose if the amount of magnesia exceeds 10 per cent. Generally, magnesian limestones yield "poor" limes.

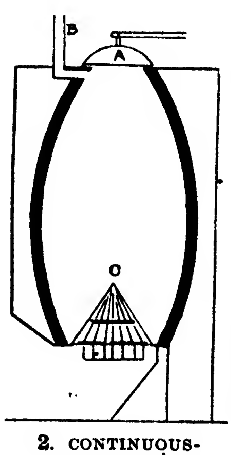
Lime Burning. The burning of chalk or limestone is carried on in kilns of simple construction. The kiln may be worked intermittently or continuously. In the first case, the kiln is cup-shaped, and is filled with blocks of chalk or limestone in such a manner that a space is left underneath for the fire [1]. For this purpose some large blocks are chosen and built into the form of an arch, which supports the rest of the stone above. In some cases such a kiln is very simply constructed from blocks of limestone, built in the form of a conical kiln open at the top, and coated inside and outside with clay. Where, however, a more permanent kiln is required a brick structure may be employed, the inner lining being composed of fire-bricks [1]. The ash of the burnt fuel in this type of kiln does not come in contact with the lime, which is, of course, an advantage. This form of kiln is known in this country as a "flare" kiln; the operation is carried on with a fire producing a long flame.



1. PRIMITIVE FLARE KILN

With more modern kilns built on these lines a properly constructed hearth, formed of arches of fire-brick, replaces the arch made from the limestone itself. Otherwise, the process is very similar.

The continuous method of burning is carried on in kilns, sometimes called "running" kilns. They are built higher than those already described, and the limestone and fuel are tipped into the kiln in alternate layers. As fast as the burning lime is removed from the bottom of the kiln, sufficient quantities of fresh limestone and fuel are fed into the top. These kilns, of course, have one drawback—the ashes of the fuel mix with the lime; but the process, being continuous, is more economical, and there is not the loss of heat unavoidably incurred when working flare kilns, where it is necessary to allow the kiln to cool down after each operation.

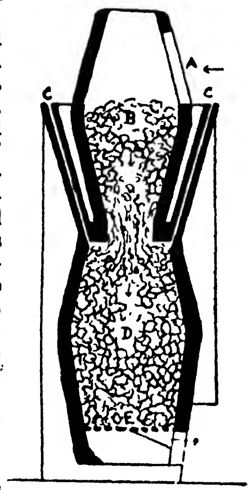


2. CONTINUOUS-BURNING KILN

Fuel for Lime Burning. Where wood is cheap, it forms a suitable fuel for some lime kilns, especially for the flare kilns. For the running kilns, coke is preferable to coal, as it usually gives a much purer and whiter lime. The quantity of fuel required varies very much with the efficiency of the kiln. A simple form of kiln will require one part of fuel to about every four parts of limestone.

With a more efficient type of kiln, the average quantity of coal burnt will vary from two to four parts for every 10 parts of burnt lime. Such a kiln may be built, say, 30 ft. high, in the form of a hollow spindle narrowing down at the top and bottom [2]. At the top there is a movable cover (A) for keeping off the draught during the burning, which can be opened for charging. The holes at the sides near the top draw off the fumes to a short chimney (B). Inside at the bottom is a conical shaped grate (C) of iron bars, the quicklime being drawn away from around this.

Modern Lime Kilns. A new and very efficient form of running kiln, constructed by Smidth, of Copenhagen, is shown in 3. It is devised with special attention to economy of fuel, and is best adapted to work a hard stone. The kiln is constructed in two halves, of which the upper (B) serves as a reservoir for limestone, which is introduced through an "eyehole" at A. Unlike the running kilns already described, only a small portion of the fuel is mixed with the limestone when put into the kiln, the greater part being introduced by the shafts (CC). The waste heat given off by the combustion going on in the lower chamber (D) is mostly retained by the limestone in B. At the bottom of the chamber (D), which is lined with fire-bricks, is a grate (E) with movable door, by means of which the burnt lime is withdrawn. The coal consumption of such a kiln should not exceed 20 per cent. of the burnt lime. We may mention that this is not the most suitable form of kiln for working a soft stone, as the movement of the stones down the kiln breaks and crushes them, and a considerable proportion of the output is reduced to a powder. Lime in good, large blocks finds a better market than broken stuff.



3. LATEST FORM OF CONTINUOUS LIME KILN

A very good form of kiln to use where lumps are required is the Hoffmann kiln. We have explained the construction and working of this kiln in the BRICKMAKING course, and have drawn attention to the very efficient manner in which the fuel is economised. We refer to it again in our consideration of cement, as it is used for burning cement as well as for bricks and lime.

At the Buxton Lime Works the chambers are filled with blocks of limestone, piled up in the same manner as if charged with green bricks, care being taken to leave the necessary channels for the air draft through the chambers, and for the fuel dropped in from the top.

The lumps of stone are carefully chosen, and vary in size—they may be as small as a man's fist, or as large as his head. The drawback is the cost of labour, which must be considerable, as the chambers are "stacked" and "drawn" by hand. Still, there is a minimum of dust and small, broken pieces. Lime burnt in Hoffmann kilns, although effecting a considerable saving in fuel over the old flare kilns, has the disadvantage that the ash of the fuel mixes with the lime. The advantages and disadvantages of the three types of kiln may be summed up somewhat as follows.

Flare Kiln. Lime is in large lumps, free from ash, but the process wastes fuel.

Running Kiln. Lime is much broken into small pieces, and mixed with ash, but the process economises fuel.

Hoffmann Kiln. Lime is in large lumps and mixed with ash. The process economises fuel, but the cost of labour is heavy.

There are also continuous kilns, in which the fuel does not come into contact with the lime.

Some of the more modern kilns have been devised to burn the lime by means of producer gas.

Quicklime and Slaked Lime. As we have already explained, the lime varies in quality according to the chalk or limestone from which it was derived. The fat limes obtained from pure materials are remarkable on account of the vigorous manner in which they combine with water. To this process the term "slaking" is given. It consists, chemically speaking, in conversion of the quicklime (oxide of calcium) into hydroxide (also known as hydrate) by combination with water:

$$\underset{\text{Quicklime}}{\underline{CaO}} \quad + \quad \underset{\text{Water}}{\underline{H_2O}} \qquad \underset{\text{Slaked lime}}{\underline{Ca(OH)_2}}$$

There is one point we should notice which is not always sufficiently appreciated—namely, that in slaked lime the water is in chemical combination with the lime. If we slake quicklime with exactly the right amount of water, the resulting slaked lime is a *dry* powder.

As will be seen, 100 parts of lime will require 32 parts of water, which is, roughly, a third by weight. When such water is added to a pure or fat lime, the lime begins to swell and get hot, giving off steam; the lumps crack, and, eventually, the hard block falls to a fine powder.

This slaking of lime is accompanied by an increase in volume. Thus, 100 parts of fat lime will give 250 to 300 parts of slaked lime. Poor limes and hydraulic limes do not slake readily, and a process which occupies a few hours with fat lime may take days in the case of hydraulic limes. The larger the proportion of clay and silicious matter contained in the chalk or limestone, the more hydraulic the lime, and the less it resembles fat lime.

Magnesium limestones give poor limes. If the percentage of magnesium exceed 10, the lime slakes slowly, and anything like 20 to 30 per cent. of magnesia makes the lime practically useless.

On the other hand, it is stated that some good hydraulic lime has been prepared from magnesia limestones. The lime, however, requires to be rather more strongly burnt.

A fat lime is easier to produce than a hydraulic lime. The larger the percentage of clay and siliciousmaterial, the lower the melting point. Hence, in burning hydraulic limes, if the temperature be not carefully regulated, it may rise sufficiently to fuse partially or to over-burn the lime; or, in other words, "clinker it." The hydraulic limes do not swell to the extent that the fat limes do when slaked. A hundred parts of hydraulic lime will yield somewhere about 150 parts of slaked lime.

The terms "hydraulic" lime and "intermediate" lime appear to cover much the same ground. By hydraulic lime, we understand a lime which is capable of setting under water. An intermediate lime is one made by burning a limestone or chalk containing some clayey matter, owing to which the resultant lime holds a position somewhere between a fat lime and a true cement. [See CEMENT.]

Hydraulic Limes. As we have already explained, limes obtained from chalk or limestone, with a suitable percentage of clay naturally bound up in them, yield a lime which does not slake very readily. Where limestone contains 8 to 12 per cent. of clayey matter, the lime produced is termed "moderately hydraulic," and instead of falling quickly into powder and crumbling under the action of water, it gives out little heat, and appears hardly to be affected. As a matter of fact, absorption of water does take place, and a substance is produced which gradually sets hard in the course of 5 to 20 days. If placed under water, it remains pasty.

Limes prepared from limestone containing 15 to 18 per cent. of clay may be termed hydraulic, as in the course of a few days they set to a hard mass, even under water. The mass is not so hard as that produced by Portland cement, which we shall discuss later, but has about the consistency of a soft stone. If the limestone contain as much as 20 or 30 per cent. of clay, the resulting lime is very hydraulic. It does not appear to slake at all when moistened, and the lumps do not swell. A paste gradually hardens under water in 2 or 3 days, and on further standing it gets much harder still, yielding a stone-like mass, which will stand the action of running water. These hydraulic limes approach cement in quality and behaviour, as the proportion of clay in the original limestone is increased.

Need for Care in Burning. Speaking generally, the clayey matter in the burnt lime is not in that intimate state of combination with the lime (calcium oxide), which we find in Portland cement. Nor should the temperature of the kiln be such as to fuse (or clinker) the mass. If this should take place, calcium oxide no longer combines readily with water, and the mass refuses to slake as a lime should. This is why the burning of hydraulic limes requires so much more care than the burning of fat limes. The danger of clinkering will also be increased if the lime contain much iron salts, or alkalies, owing to the formation of easily fusible silicates. As a rule, clinkered lime is fused only on the outside, and contains a core of quicklime. Even when every care is taken in slaking the lime, such particles of quicklime will remain, and, protected by an outer layer of silicate, will not slake with water, or else slake very gradually, perhaps after the lime has been converted into mortar. When this takes place, the lime swells and, expanding, cracks, bringing about the destruction of the mass.

When a mortar made from a fat lime has set, the subsequent process of hardening, or "induration," appears to be merely due to the combination of the lime with the carbonic acid of the air, with the formation of calcium carbonate.

With hydraulic limes, the induration is caused by a combination of the silica and alumina of the clayey matters in the presence of water with the lime (calcium hydroxide). These hydrated silicates and aluminates of calcium are formed subsequent to the setting of the mortar.

The peculiar effects produced by the presence of clay in the limestone are gone into more fully under the heading of CEMENT.

Slaking Lime. Mortars, for the purpose of building construction, consist of a paste of lime, mixed with sand. The first stage in the preparation of mortar is the slaking of the lime. This is conveniently effected by placing the lumps of lime in an iron basket, and immersing for a short time in water. The lime is removed before it has swollen much, and put on one side, when the slaking will complete itself, and the whole will fall to powder. Instead of doing this, the lime may be sprinkled with water, or else exposed to a moist atmosphere. Care has to be taken to use the right sort of water for slaking; such water should be free from saline matter, especially sulphate of calcium. River-water is, in most cases, suitable, but sea-water is said to retard the rate of setting. On the other hand, Smeaton used sea-water in slaking the lime used for the old Eddystone Lighthouse, with excellent results. However, on dry land, any quantity of salt in the water would probably cause "efflorescence" in the mortar if used above ground—that is to say, the saline matter would gradually crystallise out on the surface.

Mortar. Mortars were prepared by the ancients, and many of the analyses made show that such mortars did not differ essentially from those we make nowadays. The Pyramid of Cheops, in Egypt, is built of stone cemented with a sort of mortar, probably composed to a large extent of plaster of Paris. This pyramid was built somewhere about six thousand years ago. There are plenty of examples of the ancient use of mortar, as in the buildings erected by the ancient Phœnicians, Greeks, and Romans.

When making mortar care must be taken to see that the lime is thoroughly well slaked. This presents no difficulties in the case of fat limes; but hydraulic limes take several days to slake, and to promote the action, the lime after moistening should be covered over with sand to keep the heat in, and the slaked lime should be put through a sieve to remove any unslaked

lumps. Many hydraulic limes should be finely powdered before any attempt is made to slake them. If any unslaked portion should remain in the mortar after it is used, gradual slaking takes place with swelling of the lime and disruption of the mortar.

Mortar Sand. The sand used should be what is known as *sharp* sand, the particles of which are angular and not rounded or waterworn. Ground brick, or other similar material, can be used. The best proportion of sand to use depends upon the type of lime. Hydraulic limes usually require less than fat limes.

Sand is used for various reasons. Firstly, it cheapens the mortar, and secondly, it separates the particles of lime so that the carbon dioxide gas of the atmosphere can get at them. We must carefully distinguish between the *setting* and *hardening*, or *induration*. The setting is due to the absorption of the excess of water; the hardening of mortar depends upon the conversion of the lime into carbonate of calcium:

$$\underset{\text{Lime}}{CaO} + \underset{\text{Carbon dioxide}}{CO_2} = \underset{\text{Calcium carbonate}}{CaCO_3}$$

This latter forms a hard crystalline rock adhering to the particles of sand or any other rough surface. The crystals which go to form the mass may possibly adhere more strongly to the particles of sand than they do to each other, and hence mortar containing sand has a greater resistance to crushing than mortar prepared from lime alone.

Carbonic acid penetrates very slowly into a mass of mortar, and after twelve months only the outer one-eighth or quarter inch has been carbonated.

On the other hand, it has been found by analysis of very ancient mortars that there is sufficient carbonic acid in them to combine with the whole of the lime, so that presumably, given sufficient time, carbonic acid will penetrate right through a mass of mortar, converting the whole of the lime into carbonate.

Sand is also of use in that it prevents excessive shrinking of the mortar in drying.

Where hydraulic or intermediate limes are used the hardening of the mortar is due very largely to the formation of hydrated silicates already spoken of. In this form the silica is very slightly soluble, and the mortar prepared from such limes is exceedingly durable.

Use of Chemical Analysis. The chemical analysis of limes and limestones often results in yielding valuable information as to their suitability for the purpose for which they are required. We may, for instance, wish to know whether certain limestone is suitable for lime burning, and what sort of lime it will yield. These queries can, to a large extent, be answered if we first determine the proportion of lime (calcium oxide), magnesia, and silica contained in it. If the magnesia be high, the lime will be useless for most purposes; if there be very little silica, we may expect to produce a fat lime, and so on. Then again, a sample of quicklime should be tested for the proportion of free oxide of calcium and carbon dioxide. Too large a proportion of carbon dioxide will mean that the limestone has not been properly burnt, or that the quicklime has been kept too long and has consequently deteriorated owing to the absorption of carbon dioxide from the atmosphere. Slaked lime sometimes requires to be tested in a similar manner. It is also important to determine the proportion of water it contains, over and above that combined as calcium hydroxide, as, of course, we do not wish to pay for water when we are buying lime. The same methods of analysis are mostly applicable both to limestone and lime.

In the Laboratory. In the first place we can make a chemical analysis, and we shall give a brief outline of the method on the ordinary lines. The substance under examination should be dissolved in hydrochloric acid and the solution concentrated to dryness, to render the silica insoluble. On taking up with water and filtering, a residue will be left on the filter paper consisting of silica and traces of undecomposed silicates. For most purposes a further separation of this residue is unnecessary, and we may reckon the whole as silicious matter. The filtered solution is precipitated with ammonium chloride and ammonia solution. The iron and alumina are thrown down together and may be filtered off, ignited, and weighed if necessary. To the solution containing the lime and magnesia an excess of ammonia is added when ammonium oxalate precipitates the lime as calcium oxalate.

Filtered off and strongly ignited, it is converted into calcium oxide and may be weighed as such. In the filtrate from the calcium oxalate precipitate, the magnesia is precipitated as phosphate by means of sodium phosphate in a solution strongly alkaline with ammonia.

Lime in Quicklime. As we have said, quicklime is not necessarily pure oxide of calcium, and if we want to know how much of this latter is contained in a sample, we take 100 grammes and slake it completely, make up the milk of lime to half a litre, and after thoroughly agitating it, take an aliquot portion, say, 25 cubic centimétres, which will represent 1 gramme of quicklime. We then titrate this with a normal solution of oxalic acid with phenol phthalein as an indicator, shaking well after each addition of acid. [See ANALYTICAL CHEMISTRY.] The colour is discharged as soon as all the free lime has been saturated, but before any carbonate of calcium which may happen to be present is attacked. Each cubic centimétre of normal oxalic acid solution is equivalent to ·028 grammes of lime.

CLAYTON BEADLE and H. P. STEVENS

Running, Leaping, Digging, Climbing, Flying, and Swimming Mammals. The Use of the Hand and the Tail.

A SURVEY OF THE MAMMALS

We have now to consider means of progression. The Hoofed Mammals (*Ungulata*) best illustrate structural arrangements which promote great speed, and also the way in which these arrangements have been evolved. As we have seen, the remote ancestors of this group were comparatively small animals, which lived in swamps and damp forests. Their limbs were not particularly long, they were flat-footed (*plantigrade*), and possessed the full number—that is, five—of fingers and toes. Such spreading extremities, presenting a large surface, were very well adapted for progression on spongy soil, but not for great speed on a firm surface.

Fleet Mammals. For such rapid progression length of limb is a primary essential, and this has been partly attained in all hoofed forms by abandonment of the old, flat-footed attitude for a tiptoe or *digitigrade* one. At the same time, there was a gradual elongation of the different sections of the limbs, especially the hands and feet, thus converting them into jointed levers of great efficiency, as may be typically seen in deer and horses. Running, the most rapid kind of progression, differs from walking and the like in that the body actually leaves the ground altogether at regular intervals. This is chiefly the result of sudden straightening of the hind limbs, which by a strong backward push propel the body into the air, to come down again on the fore limbs.

Abolition of the Collar-bone. One result of evolution in the direction indicated has been the abolition of the collar-bones, which would be only a source of weakness in running, as the sudden descent of the body on the fore limbs means a very considerable shock. And the collar-bones are, so to speak, "struts" extending between the breast-bone and shoulder, and ill suited to resist such sudden impacts.

Spreading extremities, with the full number of digits, suitable for swamp conditions, would "give" too much to render them efficient when employed for rapid movement in a tiptoe attitude on firm surfaces. In the course of evolution this difficulty has been got over by more or less reduction in the number of digits, with increasing size and specialisation in those remaining. To make matters clear, it is necessary to mention here that the digits are numbered 1, 2, 3, 4, and 5, No. 1 being the thumb or great toe, as the case may be. In all hoofed mammals the digits have developed broad hoofs, presenting a firm and sufficiently broad surface for application to the ground. But there have been two lines of evolution, represented by the *even-toed* and *odd-toed* forms respectively.

The Hand of the Pig. In *even-toed* forms digits 3 and 4 have become more or less dominant, and the axis of symmetry runs *between* them. If we examine the hand of a pig we shall find that the thumb has disappeared altogether, while digits 2 and 5 (the outer ones) are much smaller than 3 and 4, which are the chief agents of progression. But as these creatures have not altogether weaned themselves from the old swamp life, the smaller, outer digits come in handy upon soft ground, preventing their owner from sinking in too far. The palm bones (*metacarpals*), which come between the small, irregular bones of the wrist and the finger bones, are moderately elongated. The peccaries of South America are faster runners than ordinary pigs, and we find that their limbs are somewhat longer and more specialised. The hippopotamus, which has to climb the muddy banks of its native rivers, is practically constructed on the pig-type. In this and the subsequent examples the fore limb is taken, but, except where specially mentioned, the hind limb is fashioned in much the same way.

The Hand of the Deer. Turning now to deer, the embodiment of swift progression, we shall find the limbs slender and much elongated, while the hand presents great specialisations as compared with a pig. The outer digits (2 and 5) are reduced to insignificant vestiges, evidently on the way to complete disappearance. And the palm bones of 3 and 4 are much elongated, and fused together into a "cannon bone," which gives greater firmness than if they remained separate. There is not nearly so much specialisation in the pigmy swamp deer (*tragulines*) native to West Africa and South-east Asia.

Ruminants that Climb. Among ruminants a place of security in which to chew the cud is a matter of considerable importance, and we find that the even-toed foot lends itself to this end by proving an admirable climbing organ, as, for instance, in some antelopes, such as the Alpine chamois, wild sheep, and wild goats.

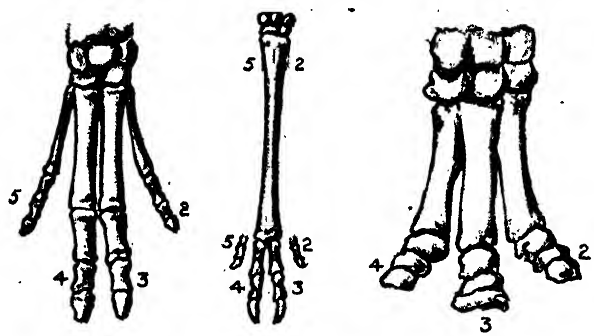
The camel presents a further point of interest in the modification of its extremities to fit them for progression on hot desert sands. Only the two central digits, 3 and 4, are present, and these diverge somewhat, so as to give a firm support to a rounded elastic pad on the under side of the foot. In *odd-toed* forms the middle digit, 3, is more or less dominant, and the axis of symmetry runs down its centre. Examination of the hand of a tapir, the most primitive existing type of the group, shows that the thumb has entirely disappeared, while the central digit is the largest and most important. The foot is still more modified, for it has lost the little toe, 5, as well.

Spreading Toes. The hand of a rhinoceros shows further reduction, for not only has it lost the thumb, but also the little finger, and the foot is on the same model. Just as the two spreading

toes of a wild goat are advantageous for climbing, so are the three spreading toes of the rhinoceros of use for rapid progression on a stony surface.

The Long Hand of the Horse. The horse and its allies constitute the last term in the perfecting of the odd-toed type of foot for rapid progression on a firm surface. In the hand we find the central digit, 3, practically the only one, is of very large size, and its palm bone is much elongated. On either side of this we note, on dissection, however, a narrow "splint bone." The two splint bones are no other than the remains of digits 2 and 4, which have almost disappeared. The elongation of hand and foot is very noteworthy, and the so-called "knee" of a horse is really its wrist, while the "hock" [see page 1628] corresponds to the ankle. Our one-toed horses were preceded in time by three-toed ones, and we can trace descent of these, step by step, from the primeval swamp-dwellers to which reference has so often been made.

Leaping Mammals. Members of several orders of mammals chiefly progress by means of the hind limbs only, which are of quite disproportionate length, and used for the execution of a series of long leaps. The kangaroo is the best-known example, and its long, thick tail is employed as a balancing organ, useful also as a support in the intervals to rest. Some of the African desert types have evolved on somewhat similar lines—for instance, the jerboas, which belong to the order of Gnawers (*Rodentia*), and the jumping-shrews, which are classed with the Insect-eaters (*Insectivora*).



Pig Deer Rhinoceros
COMPARISON OF THE HANDS THREE MAMMALS

Digging Mammals. Mammals which have taken to pursue underground prey have naturally evolved on lines which have made them efficient diggers. Of this no better example could be taken than that of our native mole, a member of the Insect-eaters (*Insectivora*). The general shape of the body is adapted to a subterranean life, and the short, strong limbs are scooping organs of great efficiency, provided with powerful digging claws. This applies more particularly to the hands, which serve as spades. There are no external ears, the eyes are very minute, and the short hairs are implanted vertically in the skin, so that there is no particular "set" to the velvety fur, which presents no obstacle to progression either forward or backward.

It is of particular interest in this connection to note that the pouched mole (*Notoryctes*) of the Australian deserts, though belonging to a totally different order (*Marsupialia*), is not unlike a common mole in appearance, being adapted in much the same way to life underground. There are also diggers among other orders of Mammalia, as rabbits and prairie "dogs" among the Gnawers (*Rodentia*), and armadillos among the Mammals Poor in Teeth (*Edentata*). In all such cases there are at least powerful digging claws.

Climbing Mammals. As a tree-life offers abundant food of both vegetable and animal nature, with fewer dangers than life on the ground, it is not surprising to find that it has been adopted by a large number of mammals belonging to different orders. More or less mobility of limb is here an advantage, and this involves, among other things, little, if any, reduction in the number of fingers and toes.

Among the Pouched Mammals (*Marsupialia*) we find the phalangers of Australia and the opossums of America are arboreal, their extremities being adapted for grasping, while in some of the latter there is a prehensile tail, serving as a sort of fifth hand. Of Mammals Poor in Teeth (*Edentata*) the leaf-eating sloths of South America live entirely among the trees, progressing head downward with complete security, for their long, curved claws give them a firm hold. In this case, it is true, the digits have been reduced, but a few efficient claws are better than a larger number of smaller size. In the same order some of the smaller South American ant-eaters also affect an arboreal life, as do some species of their Old World relatives, the pangolins, which use the overlapping scales on the under side of the tail as climbing irons.

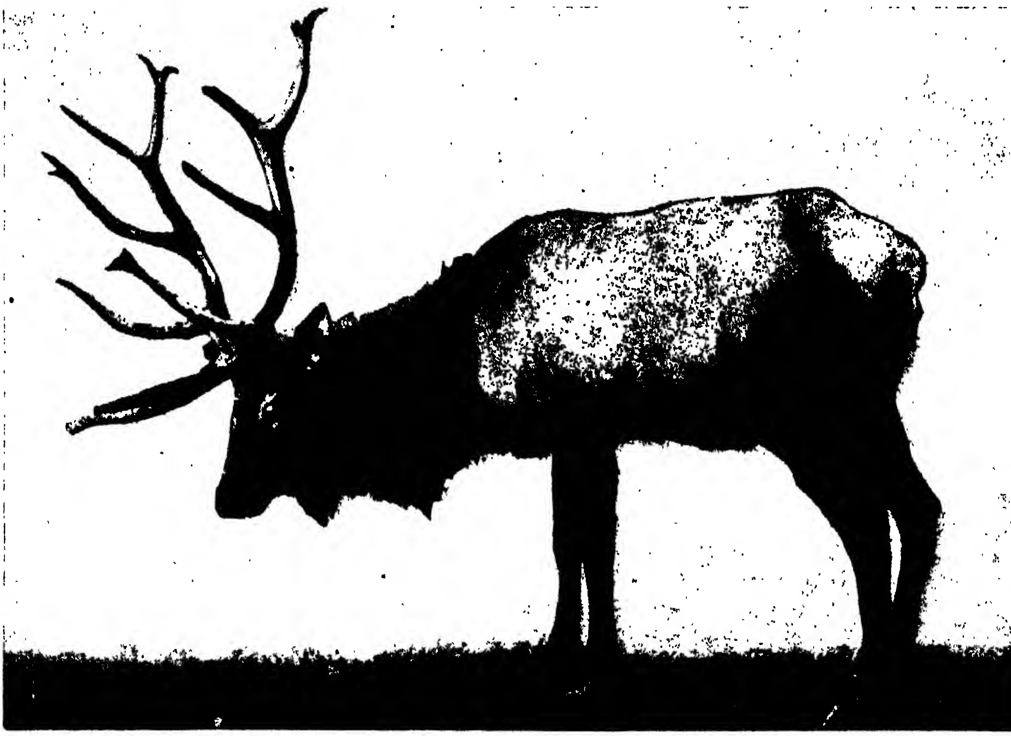
Caudal Climbing. Among climbing Insect-eaters (*Insectivora*) we find the squirrel-like tree-shrews of South-east Asia, with their bushy balancing tails; and our common squirrel illustrate the same habit among the Gnawers (*Rodentia*). In the "flying" squirrels of West Africa there are climbing scales on the under side of the base of the tail. Aided by their sharp claws, a number of the Flesh-eaters (*Carnivora*), from leopards, pumas, and cats, down to civets and some of the weasel tribe, are able to climb with facility. Some of the bears, too, can climb effectively, if clumsily.

The Monkeys (*Primates*), however, constitute the most notable climbing order of mammals, both hands and feet being able to grasp branches, as, for instance, in the orang-utan. This is mainly due to the fact that the thumb and great toe can be opposed or placed opposite to the remaining digits. Some of the American monkeys possess a prehensile tail.

Our Tree-dwelling Ancestors. There is no doubt that man himself has descended from arboreal ancestors, and in a young baby the

mobility of the toes and the inturned soles of the feet is very noticeable. The power is also possessed of supporting the entire weight of the body by grasping a stick in the hands, though readers will find that there are formidable obstacles in the way of pursuing researches in these matters on very juvenile members of the human species. It has also been plausibly suggested that the fatal instinct of throwing up the arms observable in drowning persons may be regarded as an involuntary attempt to grasp the branches of the original tree-home of mankind. The Lemurs (*Lemuroidea*), sometimes grouped with the monkeys, but in reality decidedly lower in the scale, possess climbing arrangements similar to those just described.

the Old World, while others are also found in North America, are perhaps the best-known types. Examination of such a squirrel shows that the skin at the sides of the body is drawn out into a well-marked fold, by which fore and hind limbs are united together. Smaller folds run from the fore limbs to the neck, and from the hind limbs to the base of the large bushy tail, though in some cases the latter are absent. The largest species are from 16 to 18 inches long, not reckoning the tail, which is of even greater length. When the folds are fully spread out, a very large surface is presented to the air, through which the animal is able to glide in a downward direction for nearly eighty yards. A certain amount of steering (partly by means of



A WAPITI STAG, ONE OF THE SWIFTEST OF MAMMALS

Parachuting Mammals. As elsewhere remarked, flying organs in their early stages of evolution were not used for the purposes of flight. In all probability they were, to begin with, "parachutes," by which climbing animals were enabled to descend from one branch or one tree to another with increasing facility. Such an endowment would be of obvious use in hunting for food, and also greatly help to baffle the attack of climbing carnivorous enemies. Parachuting arrangements have been separately evolved in no less than three orders of mammals —Gnawers (*Rodentia*), Insect-eaters (*Insectivora*), and Pouched Mammals (*Marsupialia*), the forms which possess them being climbers in all cases.

Flying Squirrels. Among parachuting Gnawers the "flying" squirrels of South Asia, some of which range further north in

the tail) is said to be possible, and towards the end of a descent an upward direction may be taken if it seems desirable. In this particular group there have been at least two independent evolutions of parachuting mechanisms.

The "flying" squirrels of Africa (which also possess climbing scales under the base of the tail) present similar arrangements, and there can be no question that these have been independently evolved. As in so many other cases —diggers, for instance—similar conditions of life have resulted in similar adaptations answering like purposes.

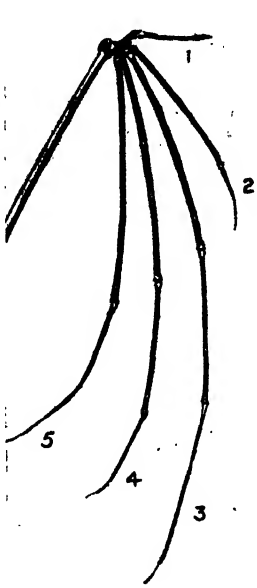
"Flying Lemurs." Among climbing Insect-eaters (*Insectivora*) we find one remarkable form in South-east Asia, the so-called "flying lemur" (*Galeopithecus*), which possesses well-developed parachuting membranes. Its

organisation is so peculiar that it enjoys the distinction of being placed in a sub-order all by itself, while the remaining insect-eaters are grouped together in another. One noteworthy feature is the possession of a well-marked "web" between the fingers, which increases the parachuting surface.

Some of the climbing phalangers of Australia, belonging to the order of Pouched Mammals (*Marsupialia*), have also evolved parachuting folds, which have earned for them the name of "flying" phalangers.

Flying Mammals. Under this heading there is but one order, that of the Bats (*Chiroptera*), and these may be looked upon as a special branch of the climbing insect-eaters, which began by parachuting, and then gradually converted their parachutes into wings.

The flying membranes of a bat are broadly similar in extent to those of a "flying" squirrel or "flying lemur," but special features of a remarkable kind are present. It is quite clear that a wing which is to be of any service must be firmly supported, so that the appropriate muscles can bring it down with sufficient force upon the air, without undue "giving." And examination of the skeleton of a bat's wing shows that this support consists of the very much elongated fingers (2 to 5), while the thumb (1) still retains its independence and possesses a strong, hooked claw, of service in climbing and scrambling.



HAND OF THE BAT

If we imagine the fingers of the webbed hand of a "flying lemur" gradually to elongate, and the extended surface thus gained to encroach upon the ordinary parachuting fold at the side of the body, we shall get a very plausible explanation of the kind of way in which the wings of bats have gradually been brought into existence by the process of evolution.

In bats, as in all other flying animals, the presence of wings is associated with the development of powerful muscles for moving them, and we accordingly find here that those in the chest region are very large. In order to give them a sufficiently large and firm surface for attachment, the under side of the breast-bone is provided with a prominent ridge or "keel." As we shall see later on, the wings of Birds and of certain extinct Reptiles are constructed on two other plans, while those of Insects differ radically from all three. This well illustrates the principle that the same biological end may be achieved by widely differing arrangements.

Swimming Mammals. The great majority of mammals are able to swim on occasion, for to do so it is only necessary for them to continue the movements which serve for progression on land. Man, unfortunately, is a notable exception to this. But there are members of several orders, and all those of two orders, which present special adaptations to an aquatic life. These are found in the general shape of the body, and extensions of surface for progressing in the water, as by flattening of the tail and webbing of the feet. At the same time the hairy covering is either short and dense, or it may be greatly reduced, the eyes are small, as also are the external ears, and the nostrils are valvular.

One of the two members of the order of Egg-laying Mammals (*Monotremata*), the duck-billed platypus (*Ornithorhynchus*), is thoroughly aquatic in habit, as may be seen by its short, thick-set fur, its webbed extremities (especially the front ones), its swimming tail (flattened from above downwards), its small eyes, valvular nostrils, and entire lack of external ears.

A Huge Swimmer. Among the Pouched Mammals (*Marsupialia*) we find a small opossum (*Chironectes*), native to Central and South America, which feeds upon fishes, and possesses webbed hind feet as well as a long, strong swimming tail. The most notable swimmer among the Hoofed Mammals (*Ungulata*) is the hippopotamus, in which the hair is scanty, while the four-toed feet are of sufficiently spread nature to serve as paddles. The valvular nostrils are on the top of the snout.

Some of the Insect-eaters (*Insectivora*) are also expert swimmers, among these being our native water-shrew (*Crossopus fodiens*), in which the hands and feet are fringed with stiff hairs which give an extension of surface. Much more highly specialised is the insectivorous otter (*Potamogale*) of West Africa, with its dense fur, small eyes, and valvular nostrils. The feet are not webbed, and the swimming organ is the powerful tail, which is compressed from side to side. Not dissimilar in some ways are the desmans (*Myogale*) of Spain and Russia, with webbed hind feet and strong tails. Gnawers (*Rodentia*) also add their quota to the aquatic community. The capybara (*Hydrochœrus*) of South America, for instance, the largest living member of the order, possesses partially webbed feet, while our native water-rat, or rather water-vole (*Microtus amphibius*), is an expert swimmer, although its feet are not webbed. The hind limbs are the active agents of progression.

Aquatic Flesh-eaters. From the forms already mentioned we pass to others, a remarkable series of which belong to the Flesh-eaters (*Carnivora*). The otter (*Lutra*), with its webbed feet, powerful swimming tail, and small ears, is a case in point. The rare sea-otter (*Enhydris*) of the North Pacific is constructed on somewhat similar lines. One entire subdivision of the order (*Pinnipedia*) contains

MAMMALS OF PRAIRIE, FOREST, AND RIVER

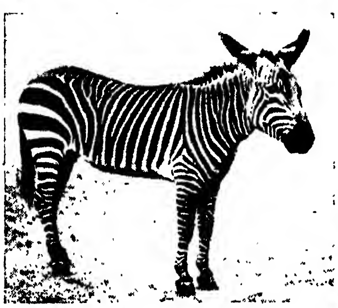
RHINOCEROS

TIGER

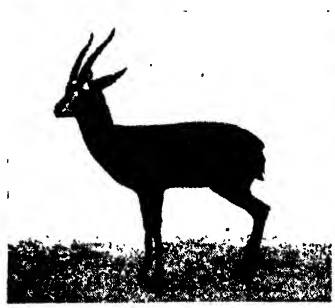
BROWN BEAR

LION

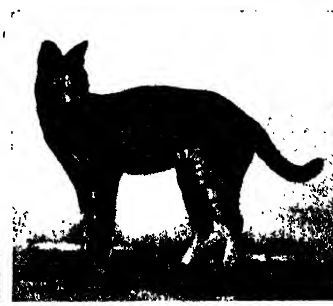
WALLABY



MOUNTAIN ZEBRA



INDIAN GAZELLE



SERVAL

BUFFALO

HIPPOPOTAMUS

aquatic animals only. All are distinguished by the possession of a thick coat of fat (blubber) beneath the skin, which is intelligible if we remember the cold regions in which they mostly live. The huge walrus (*Trichechus*) possesses paddle-like limbs, and its hair is very scanty.

The sea lions (*Otaria*) are somewhat more specialised on the same lines, except that, like ordinary seals, their fur is extremely close-set. These forms are also called "eared seals," because they still possess small external ears. In both walrus and sea-lion the hind flippers can be turned forward to assist in a shuffling kind of progression on land or ice, while the former uses its tusks to some extent to help itself along in rough places. From these we pass on to the true seals (*Phoca*), in which the hind flippers are directed backward, and bound up by folds of skin with the short tail, to constitute a very powerful paddle. This specialisation, though admirable for swimming purposes, is, of course, a hindrance to progression on land, over which the true seals make their way by a mixture of crawling and springing.

Fresh-water Seals. But little is known of the remote ancestry of Pinnipedes, but one of the ancient flesh-eaters (*Creodonta*), native to North America, possessed somewhat seal-like extremities. This creature (*Patriofelis*) was a lake-dweller, and appears to have lived upon fresh-water tortoises. It is, therefore, not unlikely that seals and their allies were first evolved in fresh water, from which they ultimately made their way into the open ocean. Seals are now found in some inland seas, such as the Caspian, Sea of Aral, and Lake Baikal, but this has a different significance, for we know that in comparatively recent geological times these bodies of water have been cut off from the ocean of which they once formed a part.

An interesting parallel is afforded by Lake Tanganyika, which is inhabited not only by ordinary fresh-water forms, but also by jelly-fishes, certain molluscs, and the like, which are characteristically marine. We may regard the lake, in fact, as a separated part of the Indian Ocean.

The Manatee. The order of Sea-cows (*Sirenia*) includes only the manatee and the dugong, both of which are purely aquatic. The fore limbs are flippers, and the absence of hind limbs is compensated for by the broadening out of the tail in a horizontal direction. The hair is very scanty, the valvular nostrils are on the top of the snout, and external ears are entirely absent. There is a thick layer of blubber. The tail of the manatee is rounded, while that of the dugong is produced into a pointed "fluke" on either side as in whales and their allies.

Mammals that Resemble Fishes. We come lastly to the Whales and Porpoises (*Cetacea*), which are still more perfectly adapted to an aquatic life. We note in a porpoise, for example, the fish-like shape, well adapted for rapid progression through the water, and the smooth, practically hairless skin (beneath which is a thick layer of blubber). The fore limbs are flippers and the broad tail is horizontally flattened, being shaped like that of a fish except that it is not vertical. Hind limbs and external ears are entirely absent, and the eyes are small. The nostrils of Cetaceans are represented by a single or double "blow-hole," of valvular nature, right on the top of the head—an obvious convenience for breathing air with most of the body submerged. The "spout" which issues from the blow-hole is not a column of water, as often erroneously supposed, but the chilled and condensed vapour of the expired air.

BRITAIN'S LARGEST MAMMALS—WHALES CAPTURED OFF THE SHETLAND ISLANDS

Origin of Marine Mammals. There can be no doubt that Cetaceans are the much modified descendants of land animals which have wrested the sovereignty of the sea from marine reptiles now long extinct. Unfortunately the geological record has not, so far, supplied us with all the evolutionary stages of this ancient group, but it can be definitely asserted that the oldest types are in some anatomical features rather nearer land mammals than those existing at the present day. It is, however, a matter of opinion whether they are more closely allied to Hoofed Mammals or Flesh-eaters. Most probably all three groups have descended from the same immensely ancient primeval stock, of which at present we have no certain knowledge.

J. R. AINSWORTH-DAVIS

Types of Railway Service. Methods of Electric Propulsion. Collection of Current.

ELECTRIC RAILWAYS

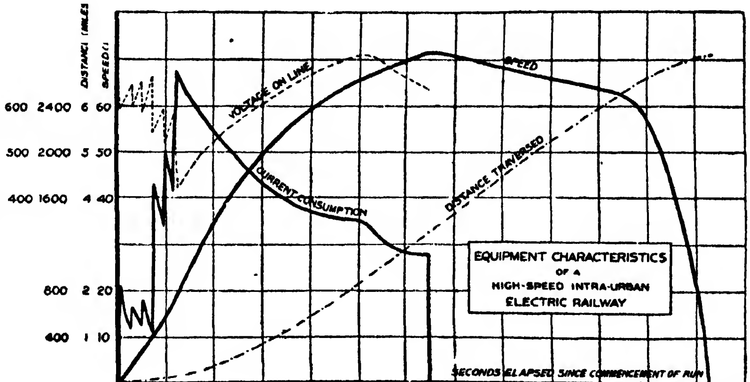
THE problem of railway electrification covers so wide a field and involves so many considerations that it is not possible in this chapter to do more than refer to its chief characteristics. Its importance may be gauged by the fact that in this country alone over 220 route miles of line are electrically operated, and several other large schemes are in progress. On the Continent and in the United States the number of important lines partly or wholly electrified is considerable.

Modern railway service may be roughly classified under two headings, namely (*a*) main-line services in which the stations are some miles apart; and (*b*) suburban services, where the stops are often as frequent as three or four to the mile. While electric methods have been successfully applied to both classes of service, it is in suburban work, in this country at least, that electricity has won its most conspicuous traction triumphs.

The Suburban Service Problem. All travel must nowadays be expeditious. To attain a high-speed main-line service one requires only to arrange for a high maximum speed without much regard to starting and stopping. For suburban service, however, attention to these last is all-important, for whereas in the previous case the train is running for most of its time at its top speed, in this case the maximum speed can be kept up only for short periods, for a large part of the time between stations is taken in speeding up or accelerating the train after a stop and in slowing down or retarding it for the next stop. It is obvious that time, under these conditions, can be saved only by getting up to the maximum speed as quickly as possible, and by bringing the train to rest as quickly as possible. These questions of acceleration and retardation become more and more important as we deal with the systems in which the stations are nearer and nearer together. To illustrate this point from actual practice, an experiment, from which the curves in 160 have been plotted, was carried out a few years ago, and a steam train made a series of journeys of varying lengths over a level piece of track, and observations were made of the time taken. The train was first taken a quarter of a mile from a station, and the driver was instructed to run to and stop at the station as in actual service, and the times and speeds were noted. The train was then taken half a mile away, and was run into the station as before, and the experiments were continued in this way until the run was for two and a half miles. In **160**, distances from the start of each run were plotted horizontally and speeds in miles per hour are plotted vertically. We learn from the curves that this train with the type of engine used had a maximum speed just under 40 miles per hour, and that it required to travel half a mile before this speed was attained. In consequence of this, and also of the time spent in braking, the average speed was much reduced, as shown by the final results worked out in the following table.

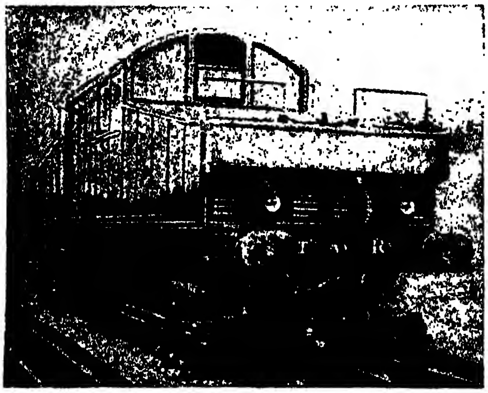
Distance between stops (miles).	Maximum speed attained during run (miles per hour).	Average speed during run (miles per hour).
¼	20	15·3
½	27·5	20·8
¾	31·7	24·2
1	35	28·6
1¼	37·2	28·6
1½	38·5	30·1
1¾	39·5	31·3
2	39·5	32·3
2¼	39·5	33·1
2½	39·5	33·7

Advantages of Electric Traction. It will be seen from the above how necessary high accelerating power is on suburban trains. The time taken on the journey depends very largely on the train rapidly acquiring full speed and being as rapidly brought to a standstill. On this, too, depends the allowable headway necessary between the trains, which in its turn determines the carrying power of the line.



157. ELECTRIC RAILROAD CHARACTERISTICS

Anyone standing on the platform of, say, the London District Railway stations during the rush hours, and watching the arrival and departure of long trains every minute and a half or so, will



158. ELECTRIC LOCOMOTIVE

learn much as to the change which the adoption of electrical traction has made possible. The average accelerating power usual on electrical lines is about 50 per cent. higher than the average on steam lines of the same class.

Another advantage which electricity possesses is its cleanliness. No smoke or products of combustion are given off on the train; and this makes it an ideal motive power for tunnel or tube railways. A further point in its favour is the ease with which trains may be made up to suit the traffic, each car, or each second car, being a motor coach. Hence by adding pairs of coaches any demand may be met without uselessly running empty coaches.

Railroad Characteristics. Just as we plotted a set of curves [139, page 1813] to show the characteristic properties of a series motor, so, in order to show the performance of a certain equipment on a certain railway, the railway engineer plots a set of curves such as is shown in diagram 157.

The various curves are plotted to a common time base, generally graduated in seconds, and the various curves represent (*a*) the current consumed from instant to instant, (*b*) the voltage on the motors, (*c*) the speed of the train during the run, and sometimes (*d*) the total distance traversed from the starting point. By reference to these curves we can see at a glance whether the equipment has been used in a proper manner or whether it is suitable for the work in hand. Let us consider the current curve. At the start it consists of a series of irregular peaks, showing how the current increases when successive resistances are cut out by the controller, and how it then decreases as the train acquires more speed. After the final running notch is reached the current then continuously decreases until, at a certain distance from the end of the run, it is shut off altogether, and the train is allowed to coast for the rest of the journey until the brakes are applied as it enters the station.

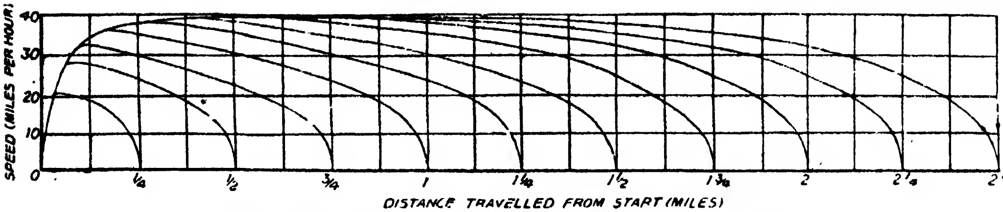
Looking at the voltage curve, we see that every time the current rises the voltage goes down owing to the increased voltage drop in the rails and feeding cables. The speed curve is the most interesting of all, in that by its initial slope we gauge the quickness with which the train gets under way at starting and the quickness with which it is brought to rest. We can also state the proportion of the time during which it was running at full speed. In the curve this is about 180 seconds, or only 37 per cent. of the whole time taken on the run.

Electric Traction. There are three systems of electric traction in use, namely (*a*) the continuous current, (*b*) the single-phase alternating, and (*c*) the three-phase alternating. All have features which make them specially successful in particular cases.

The Continuous Current System. This is the system in most general use in Great Britain, 182 out of the 220 miles of electric railways in this country using it. These 182 miles include the London Metropolitan and District Railways, the various tube railways, the Lancashire and Yorkshire Liverpool to Southport line, the Mersey Railway, the Liverpool overhead line, and the electrified sections of the North-Eastern Railway at Newcastle-on-Tyne.

It is usual to generate the current as three-phase, at high tension, and to transmit it at 5000 or 6000 volts to selected sub-stations placed at suitable points along the route of the line. Motor-generators or rotary converters are placed in these sub-stations, generating continuous currents, at 600 or 650 volts, to supply

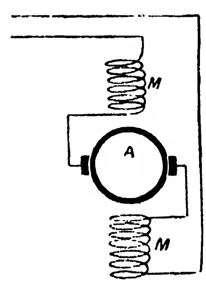
159. MOTOR COACH ON THE LANCASHIRE AND YORKSHIRE RAILWAY



160. SPEED TESTS ON STEAM TRAIN FOR VARYING RUNS

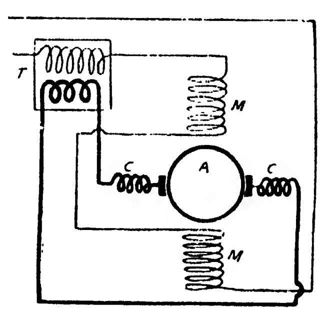
the third rail placed near the running rails, but insulated from them as shown in **163**.

The return path either to the main station or sub-station is by a fourth rail which, as in the example illustrated, is placed between the running rails. Motors, varying in power from 60 to 150 h.-p., according to the character of the line, are placed in every second or third coach, and means are provided for the control of all the motors from the driver's cab. This control is by series-parallel connection, as in the case of tramways, the main switches under each motor coach being operated electromagnetically by a small control circuit. This system is fairly simple, but in districts where the traffic is heavy the large line currents to be dealt with necessitate a number of sub-stations, the cost of which is very heavy. To reduce these currents and make this system applicable to longer lines, higher line-voltages have been proposed and used. In the United States the General Electric Company have installed a large number of 1200-volt systems, and in some cases have used 1500 and even 2400 volts. Great care has to be taken in insulating all parts of the system; and in many cases four motors are used, which are connected in pairs, so that with a 1200-volt line the voltage across each pair of motors is 600 volts. An incidental convenience of this arrangement is the ease with which the trains can be run at full speed on the 1200-volt line in the open country, and at half speed on the 600-volt town system. On the Continent continuous current line voltages of 2000 volts have been used in several cases; and in this country Messrs. Dick Kerr and Co., Ltd., are converting a short section of the Lancashire and Yorkshire Railway so as to use motors wound for 1750 volts continuous current, with a line voltage of 3500 volts.

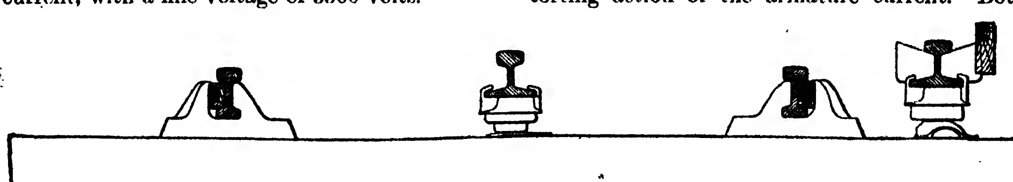


161. DIAGRAM OF SERIES MOTOR

The Single-Phase Alternating Current. This system is associated in the public mind in this country with the successful overhead installations on the London, Brighton, and South Coast Railway's South London lines, and with the Midland Railway Company's nine-mile section between Lancaster and Heysham. The currents are transmitted to the train at a pressure of 3000 volts on the Brighton Company's system, and at 6600 volts on the Heysham line. These high pressures minimise the current required and reduce the number of sub-stations necessary, but involve an expensive overhead system of conductors. The motor equipments are heavier than for continuous currents; and on the whole the cost of installation is greater for short-distance lines than that entailed for a 600-volt continuous current system. But on long lines it would probably come out lower in first cost, and cheaper in working costs. The motors which have been developed for single-phase working act in some cases on the same principle as the continuous current series motor [**161**], great care being taken thoroughly to laminate both armature core and field-magnet poles. In the United States, lines using these motors have been used in many cases on both alternating and continuous current systems, on the high pressure alternating in the country, and on the 600-volt continuous current system in the town. In other forms of motor, however, the arrangement shown in **162** is used. In this plan (*a*) the current as it goes to the armature A is transformed down to a lower voltage, at T, and (*b*) an extra winding C, called a compensating winding, is introduced on the magnet system, and is so placed that it does not necessarily produce any extra magnetism, but rather opposes the distorting action of the armature current. Both



162. DIAGRAM OF SERIES MOTOR, WITH COMPENSATING WINDING AND CURRENT TRANSFORMER



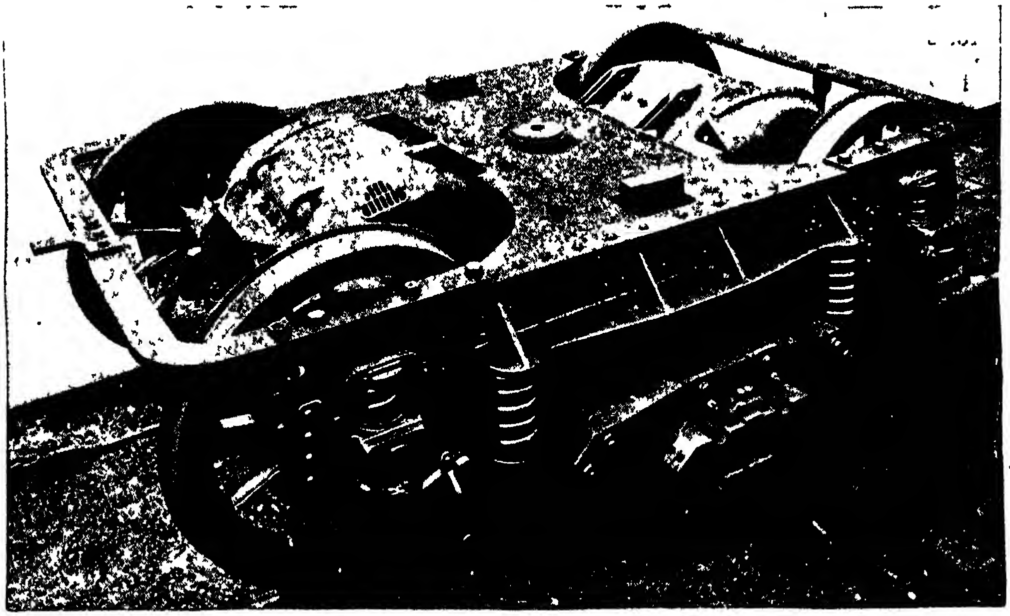
163. ARRANGEMENT OF THIRD AND FOURTH RAIL

these improvements lead to better commutation. [See mention of auxiliary poles on page 1152, and consult **96**, page 1418.]

Action of Single-Phase Railway Motor. The reason why the same motor will act in the same way when supplied with both alternating and continuous current is easily seen from the rule of the right hand explained on page 1007, where, in **49**, we have the direction of the magnetic field given as toward the left. The voltage is applied, and therefore the current flows toward us, and we see that the resulting motion is upward. This represents the state of things for continuous current or for one half—say, the positive part—of the alternating current wave [**89** and **90**, page 1288]. Now consider the case of the second half—that is, the negative part of the alternating current wave. The direction of the voltage and therefore of the flow of the current has altered, and the magnetism in consequence has also altered in direction. Now place the right hand so that the first finger points to the right and the second finger points away from one, and we shall see that the thumb, indicating the direction of motion, *still points upward*, thus showing that, in whichever direction the current flows through the machine, the direction of motion is the same, whether the current at the moment is flowing forward or backward. For further study, readers should apply the reason to the actual case of a field-magnet and a current-carrying conductor shown in **94**. It may be asked, if the direction of rotation is independent of the direction of application of the voltage, how then is the direction of rotation altered? This is done, as explained on page 1417, by reversing the connections of either the field magnets or the armature.

The method of control generally used on this system is to arrange a number of connections on the secondary of the transformer used to reduce the line voltage in the motor circuit. In this way the effective motor voltage can easily be varied at will, and consequently the speed at which the motor is running. While in the United States the single-phase system has lost some of its popularity, owing to the claims of the high-tension continuous current, some very large schemes are being planned on this system on the Continent.

The Three-Phase System. The three phase motor has been successfully applied to traction work in Italy and a few other places. The extent to which it has been adopted on the Government railways in the north of Italy is shown by the fact that there are over 200,000 horse-power of rail motors either in use or in process of construction [**165**].



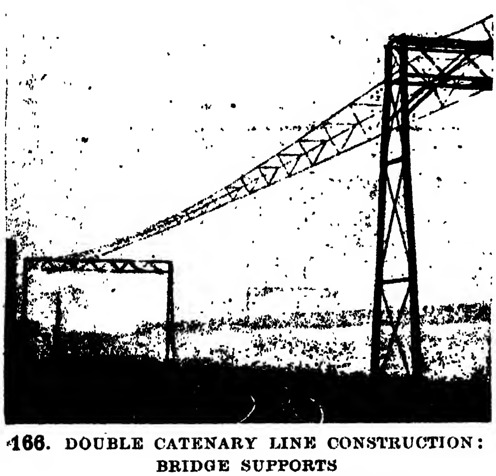
164. MOTOR TRUCK ON THE LANCASHIRE AND YORKSHIRE RAILWAY

The three-phase motor has several marked advantages for railway work. Being of the induction type, the motor has, if wound as a squirrel cage, no moving, rubbing electrical contacts whatever; while as a slip-ring motor the collected currents are of low voltage and have no direct connection with the line current. Consequently no transformers are needed, the line current at 3000 or even 5000 volts passing directly round the stator of the motor. Another point is that the motor runs at a certain speed whatever the load, and it is therefore possible to maintain a high scheduled speed all along the route. The maximum speed depends, of course, on the frequency of the supply and on the number of poles on the motor; and these have to be considered when the line is planned out. An advantage with the three-phase motor is that when running downhill it may be made

to act as a generator, the current thus produced being returned to the line, not dissipated in resistances as in the case of series-wound continuous current motors. It is said that in this way 17 per cent. can be saved on the cost of the coal bill. With three-phase traction, however, at least two overhead high-tension wires are required [165]. This means that the rails are used as the third conductor, or else that an insulated third rail is provided for this purpose.

165. THREE-PHASE LOCOMOTIVE AND TRAIN

The Cascade Connection of Motors. In places such as level crossings, where the insulated rail has to be discontinued, the two overhead lines can temporarily run the motors as single-phase induction motors; but the performance of these motors under these conditions is not satisfactory for more than a few minutes at a time. It is possible by the use of what is termed the *cascade* connection of motors to run at two speeds; and recently, by arranging the motors so that they can be used with different numbers of poles, Messrs. Ganz and the Oerlikon Company have been able to obtain economically four and even more speeds. Ordinary regulation is obtained by inserting resistance in the slip-ring circuit of the motor, cutting it out when synchronous speed has been obtained.



166. DOUBLE CATENARY LINE CONSTRUCTION: BRIDGE SUPPORTS

The Collection of the Current. The third and fourth rail methods of collecting the current generally, used in cases where the 600-volt continuous current is employed, have already been referred to. When higher voltages are used whether continuous, single-phase, or three-phase, the catenary method of suspending the live wire is usually adopted. This consists, as shown in 166, of a copper wire which, from a current-carrying point of view, may be smaller than that used on tramways, is not directly supported from the poles by ears, as shown on page 1817, but is suspended from a galvanised steel wire, which in its turn is supported from the posts. Thus: (1) The copper trolley wire may be suspended without any sagging, by making the short suspending wires between it and the upper steel wire of different lengths; (2) the poles may be erected farther apart, because the strain of each span now comes upon a steel wire instead of upon a copper wire; and (3) the use of the two wires gives a smaller resistance to current passing from the feeding point to the train, and so the feeding points may be fewer.

Great care is taken, and often large sums are spent, on the line supports. On the electrified sections of the Brighton line there are steel lattice structures passing over both lines, and from these the catenary wires are suspended. On other lines a bracket suspension is employed.

Locomotives. An interesting point in electric traction is the means used to transmit the power to the trains. Practice seems to have settled down, so far as British suburban work is concerned, to the use of motor-driven coaches [159]. Fig. 164 shows one of the Lancashire and Yorkshire motor-equipped trucks, and also the arrangement of the collecting shoe at the side. There are only isolated cases of separate locomotives [158]. In America and on the Continent, however, separate electric locomotives are very generally used, and some very large and powerful examples, capable of working up to 2500 h.-p., are being built. SILVANUS P. THOMPSON

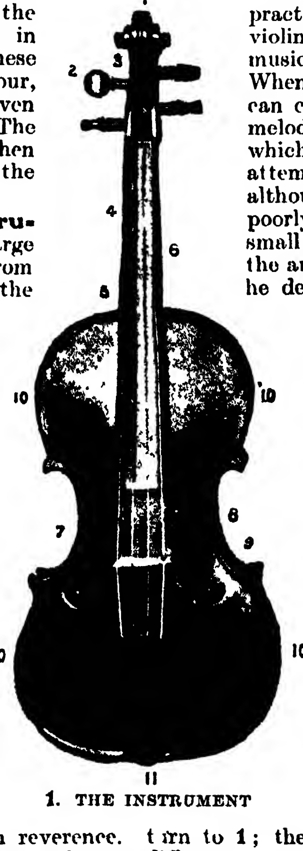
The Demands of the Instrument. Names of the Parts. Buying a Fiddle. The Strings and Bow. Tuning. Time. Exercises.

THE VIOLIN

THE precursor of the violin was the viol of the Middle Ages. As early as 1200 the word "violin" is mentioned in the legendary life of St. Christopher. It is an abbreviation of the Italian violino, the latter implying the diminutive of the great violone, or double bass. There were four chief patterns of viols. The smallest of these, termed the treble, or discant viol, was superseded by the Italian violin. The next size interpreted a deeper part. It was known then, as now, by the name of viola. Thus, our tenor violin is the only instrument of the group of fiddles retaining to-day the name borne by its predecessor in mediæval times. Certain of these tenor viols, like the viol d'amour, had seven fingerboard and seven additional strings underneath. The latter, vibrating in sympathy when those above were bowed, gave the instrument a peculiar quality.

Construction of the Instrument. The violin, whether of large or small pattern, is differentiated from all other musical instruments by the strings being set into vibration through the friction of rosined hair. In the old rota, and, later, the hurdy-gurdy, this was effected by means of a wheel instead of a bow. In the violin we have a survival of the fitter method.

Votaries of the violin point to the fact that, whereas other instruments are always being modified or improved in some way, during the past three hundred years the fiddle has undergone no change in construction. Considering that sensitive musicians are somewhat given to fault-finding, and that thousands of them have not only been entirely satisfied with the instrument, but have shown an intense love for it during that long period, the beginner may well regard it with reverence. Apart from this, since violin evening classes have been instituted by the London County Council, it is evident that we are on the eve of a popular development in violin playing. Although a temporary check may have been put on pianoforte teaching, owing to the spread of mechanical players, there is little likelihood of the inventor encroaching on the preserves of the violinist.



1. THE INSTRUMENT

Practice. The importance of the violin cannot be overestimated. It is the chief, or leader, of the group of bowed instruments which forms the basis and body of the material constituting the modern orchestra. The greatest of the composers, therefore, have made a careful study of the violin and its kindred. At the same time, although indispensable for the achievement of collective effects in a concert-room, there is no other orchestral instrument which can show such a roll of honour of world-famous solo players.

The instrument demands industrious practice. The fact that to excel on the violin is at first uphill work makes a musical hero of the successful student. When he presently discovers that he can captivate his hearers by a simple melody, after the mastery of studies which appeared impossible when first attempted, he has his reward. Thus, although violinists, as a body, may be poorly paid, the instrument itself in no small measure mentally compensates the artist by the ever-growing pleasure he derives from his close association with it.

The Parts. The pianist may win a scholarship at a chartered institution without knowing why the bent side of a grand is on the right instead of the left of the keyboard, or without being able to describe the difference between a hammer-butt and a balance-rail. But the fiddler prides himself on understanding every detail of the anatomy of the violin. As a consequence he looks after his instrument more intelligently. He is able to comprehend its many moods —for a fiddle can catch cold like a human being. If properly cared for, it recompenses the player by the extra pleasure it gives.

The student should now turn to 1; the numbers attached refer to the different parts.

The *Scroll*, or *Head* (1). Its base forms the *Peg-box.* This bears the strain of the four strings, approximating to 68 lb., but the total pull of a heavily-strung fiddle has been known to reach 80 lb. The weight of the scroll also gives as much equipoise to the instrument as the extra heaviness at the stock of a rifle makes that weapon more easy to handle. The carved curls

at either side of the cheek are called *volutes*, an architectural term denoting the spirals in Ionic and Corinthian capitals.

The *Tuning-peg* (2). It is bored in the shank with a *String-hole*. If the peg be too firm, ease it by rubbing it with a little dry soap.

The *Peg-hole* (3) is bored through both cheeks of the peg-box. The lowest hole bears the heaviest string, the next the lightest, the one above the second heaviest, and the top hole the second lightest. In this manner the strain is distributed evenly.

The *Neck* (4). This is covered in front with the ebony *Fingerboard* (6). No matter how good the tone of the *body* of the instrument may be, if the neck is not well proportioned and the fingerboard fixed at the proper angle, the cleverest player cannot make the fiddle sound to advantage.

The *Shoulder* (5). The shoulder is the part under the base of the neck. It supports the hand of the player when fingering in an upper register.

The *Belly* (10), carved in an arched or bulged-out manner, is pierced by two sound-holes (7 and 8). These, on account of their shape, are called *f holes*. The belly, being of silver pine, the most elastic of known woods, acts as a resonator, and amplifies the initial tone which comes from the strings down through the *Bridge* (9). So as to get the pulsations of the strings swinging through its two feet over the whole soundboard and the body of the instrument, it is important that the bridge should be of the right height and material. Hard beech is most satisfactory. On the top of the bridge are four *chimbs*. If these nicks get too deep, the strings, when tuned up, will rise in jerks instead of stretching smoothly. The inlaid lines, of black wood between fine strips of white plane-tree round the margin of the belly, are known as the *purfling*, which, by binding the fibres together at the border, preserve the edges of the instrument.

The "Body." The belly is connected by curved *sides*, of a carefully calculated depth, with the *back*. These three parts form the *body*, which is so graduated internally as to enclose a mass of air necessary to produce 512 vibrations per second. Jammed between the belly and the back is the *soundpost*. Without this little rod, the violin lacks its sustaining qualities. By uniting the opposite sides, the soundpost permits the circuit of vibration to complete itself, and enables the sound-waves to act and react on each other freely. Another great nerve in the fiddle under the belly is the *bass-bar*. This extends from the left foot of the bridge in a slightly slanting direction. To explain the influence of this bar, it may be mentioned that every piece of wood has a definite tone when struck, if one has the ability to hear it. The great fiddle-maker, Stradivarius, on completing a belly of sonorous pine, found that it emitted the note C. After cutting the *f* holes, the pitch was lowered half a tone to B. Thereupon, he accelerated the vibrations by adding a bass-bar. This raised the sound to D. He then reduced the thickness of the bar until the belly responded with the note he wanted, C. But if the belly sounded C he tuned the pitch of his backs to D, always a tone higher.

For the *Tailpiece* (11), glass, ivory, and various metals have all been tried, but plain ebony is best. It will be noted that between the edge of the tailpiece and the bridge there is a space of about 1¾ in. where the strings are not played upon. The length of this un-bowed portion is mathematically calculated. It has a great influence on the character of the tone. Although the bowing is done below the bridge, when the long segment of the string there is set into vibration, the unused remainder of the strings reinforces the sounds by emitting what are called overtones, which add to the brilliancy of the notes. These sympathetic upper partials may not be perceptible to ordinary ears. If a piece of heavy felt is wrapped over the strings from the tailpiece almost as far as the bridge, the difference in quality can be proved. At the broad end of the tailpiece are four slots, or eyes, to receive the ends of the strings. The outline then diminishes before it terminates. The small bulb at the end is called the *saddle*. In this are a couple of holes. These receive the *loop* of thick black gut which fits round the *tail-pin*. The latter is fixed firmly into the *tail-block*. This, before being glued into its place, furnishes a spy-hole for the maker to see that all is right inside before he closes it up.

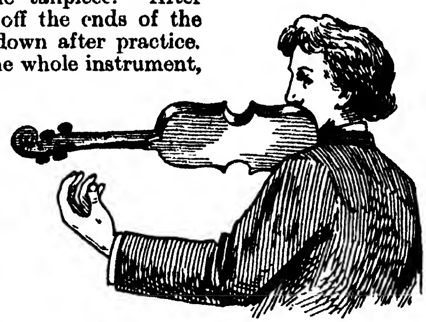
Buying a Fiddle. When choosing an instrument, do not expect to pick up a bargain for a small sum, especially at a pawnbroker's. Refrain from answering catchpenny advertisements, and disregard an old name on a label inside any instrument offered for less than two figures. In every large town a repairer of violins is to be found. Seek out such a craftsman. His tribe is invariably enthusiastic, and useful hints may be gained from him.

Because great players possess old instruments bearing famous names, it does not follow that an ancient fiddle is invariably better than a modern one. The reverse is the case if the purchase is limited to about £2. For that sum an excellent copy of a good model may be obtained from well-known London firms, such as Hill, Withers, or Hart. Unless the beginner's fingers are diminutive, it is better to get a full-sized instrument. In the former case, a three-quarter or even a half-sized instrument may be advantageous. In the latter instance, the length of the string from the bridge to the nut on the fingerboard should be approximately 13 in., and the total length of the body nearly 14 in. If the violin is required for orchestral work, choose a flatter belly than if for solo playing. A flat model has more penetration of tone. A fuller curve is calculated to produce more mellowness, or sweetness.

Strings. The same consideration applies, in a lesser degree, to the gauge of the strings used. A set of the thickest gives fulness at the expense of brilliancy, whilst the thinnest give brilliancy at the expense of fulness; moreover, the latter are more liable to break. Medium gauge is preferable. Before putting on a string, see that it has not become untwisted. Make a small loop at one end of the thinnest, or E string. Slip this through the aperture

in the tailpiece. Draw the rest of the string through the loop. With the other end, thread the eye of the tuning-peg. A pair of tweezers is useful for drawing the end through the other side. The other three strings do not require a loop; a double knot suffices to keep them in their places on the tailpiece. After screwing up the pegs, cut off the ends of the strings. Do not let them down after practice. This alters the tension on the whole instrument, and when they are screwed up again they will never keep in tune.

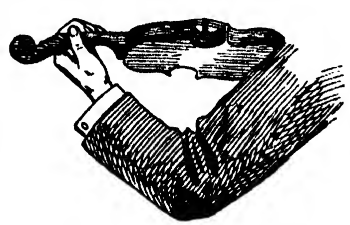
The Bow. If a serviceable violin can be purchased for £2, a suitable bow is obtainable for 5s. or less. In selecting, be careful to get a straight, flexible and light stick. The whole should not exceed 2½ oz. in weight. See that the screw works properly. The best hair is that from the tail of a white horse. One hundred hairs are used, and they should not cross over one another. The hair of horses is whiter and less greasy than that taken from mares. Some players nowadays affect very long bows, several inches in excess of those of the celebrated Tourte pattern. Avoid extremes. Choose a bow of medium length. Get a box of purified rosin for a few pence.



2. CHIN-AND-SHOULDER GRIP

Another small item usually incurred is the purchase of a "chin-rest." Great players formerly were content to make a pad of their handkerchief. But a plain ebony chin-rest gives increased firmness when holding the instrument. Spohr's fiddle-holder was fixed immediately over the tailpiece. Nowadays, the accepted place is to the left of the tailpiece over the body of the violin. An advantage claimed for the chin-rest is that it does not damp the vibration of the belly, as is partially the case when the latter is pressed by the lower jaw.

Soundpost and Bridge. Sometimes an otherwise good fiddle may sound very dull in tone owing to the wrong position of the sound-post. This little cylinder inside the instrument, as has been explained, supports the bridge, and is placed under its right foot. The middle of the left foot of the bridge must stand exactly over the bass-bar, the position and breadth of which can be discovered by a thin hooked wire being inserted through the *f* hole. A slight adjustment of the soundpost, with what is called a soundpost setter, may greatly improve the tone.



3. KEEPING THE WRIST DOWN

Or perhaps the reason of the dulness is because the bridge is too high. The outline of the top of the bridge is regulated by the arching of the belly. It always slopes more over the E string than over the one covered with wire, so as to enable the latter to be more easily bowed. The edge of the feet of the bridge should be in a line with the inner notches of the *f* holes.

Tuning. Each of the four strings of the violin has a different gauge. The thickest of the four is the D, although that does not give the lowest sound. The bass string, being artifically weighted with wire, is only a little thicker than the A, or second string. Copper-covered strings are less expensive than those with silver. Their tone is often as good, but their surface is more apt to corrode. When a gut string is put on the tone is sometimes false. This may be due to an error in the make, or to the fact that the string has perished. A dull or spotted appearance indicates the latter condition. Good strings are pale yellow, transparent, and glossy. In any case a false string is worthless. To keep spare strings in good condition, enclose them in an air-tight box wrapped in oil-silk. Always buy the best quality of strings. Avoid "acribelle," or silk strings; they are liable to fray, and their sound is generally undesirable.

Tune the second string to A—second space, treble clef—by a tuning-fork or piano. If a piano is unavailable, sets of four pitch pipes can be obtained for a small sum. If too low in sound, screw the string up gradually. It may break if the tension is increased suddenly, or the string is wound too far. When turning the peg and twanging the string, watch the bridge. If the string pulls it forward, release the strain slightly, or the bridge may fall and break.

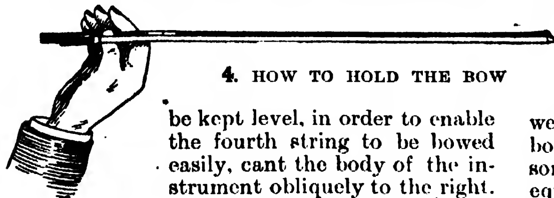
Tune the third string to D, a perfect fifth below A, and the fourth string to G, a perfect fifth below D. Lastly, tune the first string to E, a perfect fifth above the A of the second string. If it does not sound flat enough, a pressure of the thumb along the string should suffice to stretch it to the lower pitch without further screwing. If the pegs are loose and they run down, chalk will make them hold better. These four strings give the natural, or "open" notes of the violin.

Attitude. The first exercise is to learn to bow the four open notes properly. To do this, the beginner must hold himself and his violin correctly. He will be seen at his best—as well as at his worst—when he plays standing. Hold the body erect. Keep the feet slightly apart. Throw the weight on the left foot. Avoid assuming any position which is unnatural. Nothing looks worse than a fiddler who stoops, sticks out his elbows, or lets his instrument droop in front whilst he scrapes on it limply.

Left Hand. Hold the violin by its neck with the left hand. Lay the tail-end of the

instrument upon the left collar-bone. Advance the left shoulder slightly to receive the violin. Incline the head to the left; place the chin on the chin-rest to the left of the tailpiece. The grip between chin and collar-bone should be sufficient to hold the violin horizontally without assistance of the left hand [2].

It is better at first to incline the fiddle a trifle up rather than downwards. Although the axis of the violin from the tail-pin to the scroll should



4. HOW TO HOLD THE BOW

be kept level, in order to enable the fourth string to be bowed easily, cant the body of the instrument obliquely to the right. Place the left hand on the neck, with the thumb to the left and the fingers over the strings. Do not let the neck drop into the hollow of the thumb. Instead, regard the thumb and first finger as a two-pronged fork. Whatever pressure is necessary should be between the ball of the thumb and the second joint of the first finger—half-way up the prong. At the base of the fork, the player must keep a free space, so that "daylight" may show between the two digits [3].

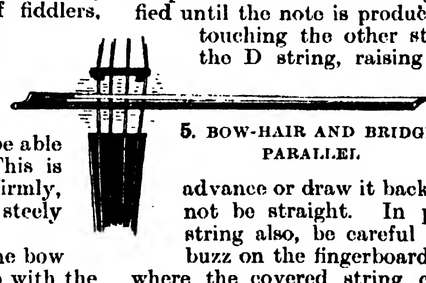
The object of this rule is to keep down the wrist as vertically as possible, well under the neck, so that, later, when the hand is shifted up the fingerboard for playing high notes, it may move freely and uniformly. The tendency of the beginner is to let the wrist advance to support the neck. This is a bad habit, and must be avoided. The instrument should not require any such assistance if held properly by the chin. The thumb acts as a rest rather than a vice when in contact with the neck.

Bend the elbow to the right, well under the centre of the instrument, without leaning it against the player's body. It constitutes a zig-zag bracket, which should be free to swing laterally. Paganini, the greatest of fiddlers, crooked his elbow in such a way that it came out at the right side of his instrument. But he was a phenomenon. In violin playing, the position should be as graceful as possible. If good tone is to result, the fingers must be able to move freely and independently. This is only possible when the fiddle is held firmly, and at the same time with a certain steely flexibility.

Right Hand. Having rosined the bow thoroughly from tip to nut, take it up with the right hand [4]. Place the thumb in the hollow in front of the nut, or screw-slide. Rest the first, second, and third fingers on the back of the stick, pointing them to the screw end much in the manner that one holds a pen. The place of the first finger is at the end of the silk wrapped round the stick, which gives it a good hold. The fingers should not touch the hair. While the first finger encompasses the stick, pressure between the second finger and thumb mainly controls the bow movements. If it is necessary to keep the joints on the left fingers well up over the strings, it is equally desirable that the right wrist should be held high, while the fingers, pointing down, are kept close together on the stick of the bow. Do not project the right elbow; hold it close to the side.

Exercise on Open Notes. Place the tip of the bow on the first string midway between the bridge and the end of the fingerboard. Press the tip on the string. Play the open note E, keeping the body steady. Push the whole length of the bow slowly upwards across the string. Instead of trying to crush the tone out of the string by means of downward weight, cultivate a lateral pressure. Pass the bow along firmly, with its stick inclined somewhat to the right, as if cutting the string equally with a sharp knife. What is wanted is not vertical, but an even sidelong weight. To get this, keep the bow parallel with the bridge and at right angles to the strings until the nut is reached [5]. As the bow ascends, curve the wrist gradually more and more; make the wrist movement artistically. If the beginner has a chance of seeing Lady Hallé play, he will understand how beautifully this can be done. The action should be light rather than heavy; but whilst supple, there should be no display of weakness. As slowly, draw down the bow until the tip again reaches the string. Throughout each bow movement, the stroke should be of equal length and equal duration. Do not be discouraged if the effect is rough and squeaky; the coarseness will diminish with practice on the beginner bearing in mind to try always to cut the string figuratively by the sharpness of the bow.

Having tried the E string, take the A. Simple as it may seem, to hold both the instrument and bow correctly requires as much self-discipline as holding a rifle in order to shoot properly. As the A string is higher than the E, begin with the nut of the bow slightly elevated, compared with its position on the first string. Do not be satisfied until the note is produced steadily without touching the other strings. Then take the D string, raising the right elbow a little; lastly, go to the G. The elbow is now more elevated; take care not to advance or draw it back, or the bowing will not be straight. In playing the fourth string also, be careful not to let the wire buzz on the fingerboard. In some fiddles, where the covered string chatters chronically under pressure of the bow, the defect has been cured by a slight hollowing of the fingerboard at its wider end, so as to give increased space for the vibrations.

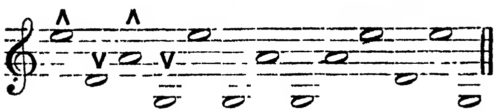


5. BOW-HAIR AND BRIDGE PARALLEL

Repeat the foregoing exercise quicker, bowing four strokes to each string. A flute player, when he practises, cannot count aloud. Make use of the advantage which the violinist has in this respect. Imagine that the beginner is a recruit on parade, and is being drilled by numbers. On

the word "one," pass the bow up its full length; on "two," bring it down firmly; on "three," pass it up again; and on "four," bring it down. Without break, continue the motion on the A, D, and G strings. After four more strokes on the G, return to the D, the A, and finish up on the E. Still counting, next proceed to leap from one open string to another, and then play two open notes at one time, thus:

Λ = Down bow. V = Up bow.



Stopping. Hitherto, the left fingers have been clear of the strings. The beginner will now begin stopping the notes. Remember, while doing so, to keep the left wrist down and get daylight between the thumb and the base of the first finger. Practise these preliminary exercises in front of a looking-glass, so as to contract no bad habits as regards position. See that the scroll of the violin is kept well up, that the bow does not sway from side to side, but passes parallel with the bridge, and that the movements of the arm and body are not jerked, but are made easily.

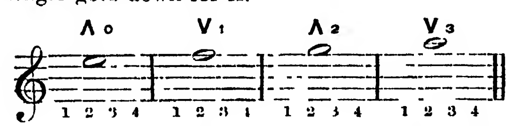
Now press down the fleshy tip of the first finger on the first string tightly, near the nut of the fingerboard, so as to form a half-tone, F, above the open note E. When the finger goes down, the violin must be kept still, and the ball of the thumb will resist the pressure. Count three. On the word "one," bow the F evenly and clearly; on "two," take off the first finger. With the down bow, play the open E. As the stopped note was less clear than the open note, try the F again with the up-bow, pressing the finger well down. Continue on the second string. On this, put down the second finger; it should produce C, a third above the open note A. Count three. On the word "one," play the C; on "two," the open A; on "three," make the C sound better than it did before. Get it well in tune. Proceed to the third string. On this, put down the third finger to produce G, a fourth above the open D. As the third finger is weak, press with emphasis. Count as before. Sound with the up-bow the stopped note G, with the down-bow the open D, repeating the up-bow in order to do better than before.

Advance to the fourth string. On this, put down the little finger to stop D, a fifth above the open G. Although the fourth finger is the smallest member of the hand, it is important to the violinist; being the smallest, it should receive special attention. Keeping the midget down firmly, on the word "one," sound the D with an up-bow; on "two," raise the little finger and play the open G; on "three," repeat the up-bow, getting a better result. Try the G string exercise again; then go back to the third string; put down the fourth finger with that also, and stop A, a fifth above the open D. Proceed to the second string, put down the third finger, sounding D, a fourth above the open A.

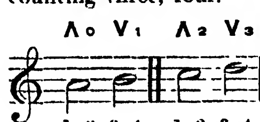
Lastly, put down the second finger on the first string, stopping G, a third above the open E. To make the motions even, it is advisable to practise with a metronome, as drummers do in the army. If a metronome is not available, regulate the strokes of the bow to so many ticks of the clock. Avoid beating time with the foot, and do not sway the body.

Time. The simplest form of time consists of alternately strong and weak accents at regular intervals. Take, for example, common time $\frac{4}{4}$, which has four crotchets in a bar. The first beat has the strongest accent and the third beat a slight accent. To appreciate this, take a baton and beat in four time. The first beat is a strong down stroke, the second a weak stroke to the left, the third a fling to the right, the fourth up.

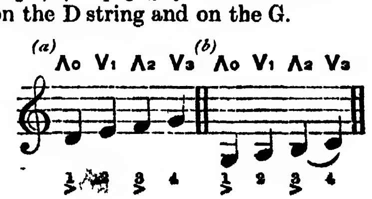
Common time is expressed in many different ways, and with many different note values. We will take the three simplest to begin with, with an exercise to each to be practised on every string. First, take the semibreve, the longest note in common use. It is equal in value to four crotchets. Draw the bow slowly across the first string E, counting four. The beginning of the down-bow must be slightly pressed on the "one." Next put the first finger down on F firmly and bow with the up-stroke, attacking the first beat. Then put the second finger down a little apart from the first to make G, the first finger remaining down as well. This is played with the down-bow, counting as before, and with the up-bow the third finger goes down for A.



Second, we will take two minims, which equal one semibreve, and count two beats to each. The bow in this case will move twice as quickly as before. Our next little exercise we will take on the second, or A string. Draw a down-bow on open A string, counting one, two, and, as you count three, the first finger must be placed on A to make B, on which you bow an up-stroke and count three, four. The next finger you put down will be the second to make C, using a down-bow and counting one, two, as before. Then on three put the third finger down, making D, which must be played with an up-bow, counting three, four.



Lastly, take four crotchets in a bar. This means a separate bow for each note, and this exercise we will take on the D string and on the G.



The Treatment of Yarn Preparatory to Weaving. The Vital Importance of a Humid Atmosphere in Weaving Sheds.

PREPARING FOR COTTON WEAVING

FACTORIES for cotton spinning are spoken of as mills, but the trade name for weaving factories is *sheds*. We have seen that cotton spinning mills are ordinarily structures of several storeys, but weaving is practically always done upon the ground floor, and for two reasons. Great vibration is set up by fast-running looms, of which usually hundreds, and sometimes thousands, are housed in one shed. Then good lighting is indispensable to good work, and the best lighting is secured by adopting a saw-toothed roof construction, glazed with thick glass, facing north. A double-storeyed edifice containing the offices, store-rooms, warehouse, and some auxiliary machinery, often fronts the shed, as it does in **1**. The illustration shows a weaving shed with its boiler and engine houses at one side, and time office at the other, with roadways for incoming and outgoing goods.

Power Used for Driving Looms. Steam-power is chiefly used for driving looms, partly because steam is cheap and the engines reliable. There are other reasons, for steam is often necessary for other work than driving the mill, as in heating and humidifying the atmosphere, or for supplying boiling water. Gas engines have been used, but the motive power that makes most headway in rivalry with steam is electricity. Individual driving by the direct coupling of motors is suitable for heavy looms, but light looms are preferably driven in groups of fifty to one hundred by a motor coupled to a shafting. The power consumed by light calico looms is not great, and it is customary to reckon that three or four absorb one horse power. As it hardly ever happens that all the looms in a large group are in motion at one time, it is customary to strike an average of the power required.

The equipment of weaving sheds varies with the class of goods woven, and the form in which the yarn is received. The largest business is done in plain goods made with yarn fresh from the spinners' hands, and though many manufacturers have spindles of their own, the larger part of the yarn woven is bought from spinning mills outside. *Manufacturer* is the name that distinguishes cloth producers from yarn producers. Weft yarn is delivered to the manufacturer upon mule cops or ring bobbins ready for the loom. Twist yarn is mainly delivered upon mule cops, from which it requires winding on to warping bobbins; but ring-spun and doubled twist are often delivered in the form of cross-wound *cheeses* [**5**], or of warps rolled in ball form, or wound upon the beam. In some circumstances the business of winding and warping falls then to the spinner, and in others to the manufacturer.

Winding Yarn for Warping. The operation of winding from a small cop or bobbin to a larger *warping* bobbin, without combining strands together or increasing the twist, is a very simple one. The yarn for winding is placed on rotating pegs carried on a bracket some little height above ground, and the ends of the yarn are led upward over a guide and wound upon the larger flanged bobbins which rotate upright upon spindles above. The guide is a moving rail which lays the yarn evenly. In transit from the cop to the bobbin, the yarn receives a certain amount of clearing by friction with a flannel-covered board or plush-covered roller, and by passing through the teeth of a wire brush.

Yarn that is to be wound from hanks is dealt with upon a split-drum winder of the same type as that described in relation to the operations of cotton doubling. The knotted hanks are opened out and placed upon the arms or *ryces* of hexagonal reels, and the end is led upward through the diagonal cleft in the drum or cylinder, and wound upon horizontal tubes into a cheese or cone. Yarn is wound also from cops or bobbins by use of a similar machine, and it is an advantage for some purposes to dispense with the flanged or two-ended warping bobbin. Crosswound yarn does not need the support of bobbin-ends, which are always liable to breakage.

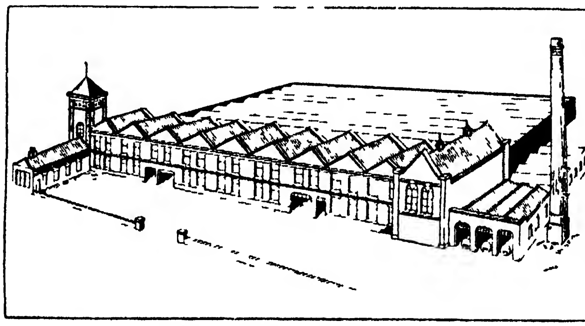
Beaming the Warp. The object of winding the warp yarn is to obtain long continuous lengths. The next step is to arrange continuous threads of a pre-determined length and number in a parallel form. They are the threads that are to run from end to end of the woven fabric. The requisite number of bobbins or cheeses to form the warp are mounted in a frame or creel, so that each is free to unwind when the yarn is pulled. This creel in the *warp-beaming machine* is a hinged structure of V-shape, from which the threads are drawn parallel through the wires of a reed, under and over tension rollers, and next through a guide comb. They are wound then upon a beam, or giant bobbin, with a wooden body having a diameter of five inches.

Warping Machines. The beaming machine [**7**] is used in preference to the old warping *mill*, of which the principal feature is a skeleton wheel or reel of up to 20 yards in circumference. The reel is mounted upon its axis vertically, and in use the threads are drawn from the stand or creel through the eyes of a *heck* or guide which directs the placing of the threads and coils them spirally around the circumference. The length is measured by the number of turns given to the mill, the threads are counted and are grouped together for convenience by *lease* threads.

The *warp-balling machine* draws yarn from the creel, and winds the parallel threads into a ball around a central tube. It does on a large scale the same kind of balling as is done on crochet cotton for retail sale, or upon twine. Warps are balled chiefly for ease in transit, or for dyeing or dressing, and have to be wound upon a beam before they can be used on a loom.

Complications are introduced when warps containing threads of different colours have to be made, and, varying with the circumstances, one machine becomes more profitable to use than another. *Section warping machines* beam or ball threads of one colour together, or in the allotted order, to make coloured stripes, the yarn being warped in sections, side by side upon a beam divided by flanges. Coloured and striped warps require *dressing*, and are carried over a simple beam and opened out by rollers. The warp dresser counts the threads and passes the ends through the dents or openings of a wire reed, removing imperfections and seeing that the colours are in the order desired.

Sizing Warps. Warps which have not been doubled need to be *sized* in order to withstand the tension and chafing that have to be undergone in the loom. A distinction is drawn between such sizing as is done solely to facilitate weaving, and that done for the purpose of increasing the weight of the cloth to a material extent. The former is called *pure*, or light sizing, and it involves simply the use of agglutinants like corn starch or flour paste. By *heavy sizing*, warps can be loaded even to 100 or 150 per cent., and the process is a considerable art. An immense trade is done in Lancashire in heavily sized goods, and about half of all the grey cotton goods sent to the Far and Near East are of this class. Beyond the increase of weight, differences of feel and appearance are created by the skilful use of size, some mixings adding to the softness or hardness, and some to the lustre.



1. A TYPICAL WEAVING MILL

The morality of sizing, at one time furiously disputed, scarcely comes into question in these days, when even savages know how to tell whether a fabric has been loaded heavily in the course of manufacture. Weight may be added, and external appearances be radically altered in finishing woven cloth, but for the present only warp-sizing, or *tape* sizing, as it is often called, is in point.

Size Mixtures. It will be understood that the strength of a pure size varies with the degree of dilution. A mixture, which when used weak only serves to strengthen and bind the fibres of the yarn, may be made to add appreciably to the weight by using it in a stiff paste. It does not follow that the course is the best one to pursue when an increase of weight is wanted, because the starches are not heavy in relation to their bulk. Variety of result is obtained in light sizing by using one form of starch in place of another, but in heavy sizing the vegetable matter is used principally to cause a mineral to adhere. Wheat flour, maize starch, rice starch, potato starch, sago, Irish moss and dextrin, or British gum, are among the ingredients employed.

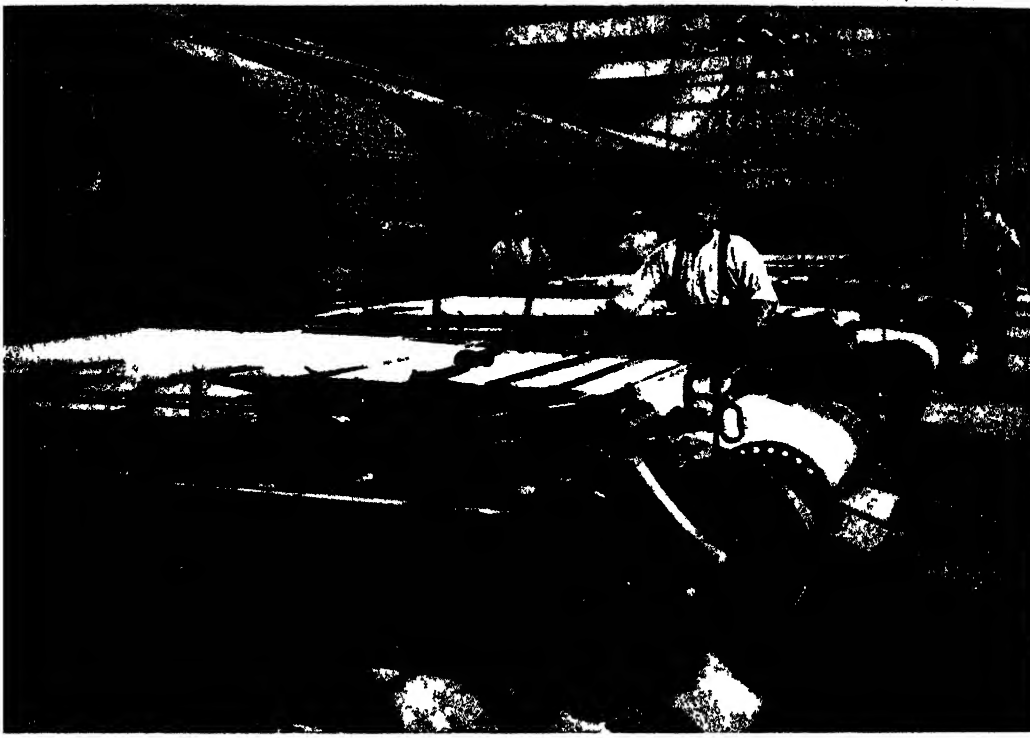
Large use is also made of gum tragasol, a product of the kernel of locust beans, valued for its tenacity. The mineral material mostly used to add weight is china clay, the potter's raw material. Sulphate of baryta, much used in surfacing paper, lends a harsher feeling, but gives more weight, to the cloth ; French chalk, although less heavy than either, lends a very slippery handle to the cloth.

Silicate of magnesia, Epsom salts, and Glauber's salts are the mineral substances chiefly used on bleached and coloured yarns. To these materials when fulness of handle is wanted, addition is made of some fat or oil. Coconut oil, paraffin wax, castor or olive oil are all used in sizing compositions, but tallow is the lubricant most often employed. Dry sizing compositions tend to rub off more readily than those which retain a little moisture. In order to keep the composition slightly moist, deliquescent salts are added, chiefly chlorides of magnesium and calcium, with or without glycerine. However, it is in the nature of pastes to go sour and to mould or mildew, and the effect of adding hygroscopic salts is to heighten the risk of trouble from this source. Cotton goods are often kept in stock for long periods in hot and moist climates, and to counteract the tendency to mildew, antiseptics are introduced. The preservative mainly employed is zinc chloride, which is without odour, and does not stain the goods, although it may provoke trouble for bleachers who have to handle the cloth later.

Preparation of Size Mixtures. The ingredients are mixed in different proportions, according to the proportion of weight to be added, and the exact character of the finish desired. Heavy sizing is an art, and the expert *taper* is the best paid workman in a weaving mill. There are an infinitude of shades of hardness and softness, and differences arise in these respects from the longer or shorter time that the mixing has been boiled. An apparatus like a barrel-churn, with inside dashers, is used to emulsify gums which mix, but do not dissolve in water. The more readily mixable ingredients are mixed in open *becks* or tanks. Wheaten flour is steeped or fermented before use, and simple starch, or starch and tallow mixtures, are made by boiling together the ingredients. For heavy sizing, the becks are arranged in a series usually of three, and fitted with mechanical agitators or dashers. The first is the steeping beck, in which several sackfuls of flour are left with water and zinc chloride for two or three weeks. The second tank is filled by pump from the first, and in this the flour paste is diluted. The third or mixing tank is that in which a boiled mixture of minerals, fats, and water is poured into the boiled and diluted flour paste. The several ingredients are all boiled together, and their specific gravity is read in Twaddell hydrometer degrees.

The strengths of sizes are spoken of in percentages, as 25 per cent., 50 per cent., or 100 per cent., these being the proportions in which they are to increase the weight of the warp. Only light sizes are used on goods needing to be dyed and finished after

PREPARING THE LOOM FOR THE WEAVER

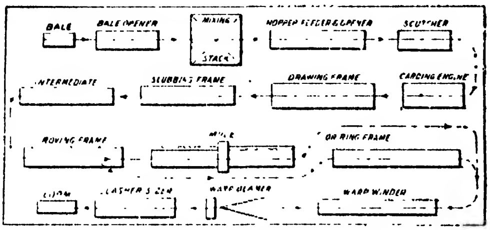


THE WARP THREADS PASSING OUT OF THE LARGE CYLINDERS, IN WHICH THEY ARE DRIED AFTER THEY HAVE BEEN SIZED, AND BEING WOUND ON THE WEAVING BEAMS

THE FINAL OPERATION BEFORE WEAVING—HEALDING THE WARP THREADS BY PASSING THEM INDIVIDUALLY THROUGH A DRAWING-IN FRAME

weaving, the medium and heavy mixings being reserved for goods to be sold *grey*. A certain loss of the added weight occurs in weaving, but to diminish this, and to prevent dust, means are taken to humidify the air in the sheds in which most cotton goods are woven.

How Yarn is Sized. The size is applied to the yarn generally by the *slasher sizing machine* [6], which is fed with warps from the beam warper, and is often arranged to receive six or eight of these *back* beams at once [2]. Yarn is drawn from two or more beams, according to the number of ends of warp



4. GENERAL SEQUENCE OF WEAVING MACHINES

required to make the cloth, and these ends are gathered together and led through the *sowe box*, or vessel containing the hot sizing mixture, where they are submerged by passing under a roller. On leaving the box, the yarn passes through squeezing rollers which serve the double purpose of removing the excess of size, and squeezing the size well into the thread. The warp travels forward round the surface of large steam-heated copper cylinders upon which the yarn is dried. On leaving these, the yarn is cooled in a fan-chamber, and, after passing through a *wraith*, or comb, to separate the ends one from another, it is wound upon the weaving beam which is later placed in the loom.

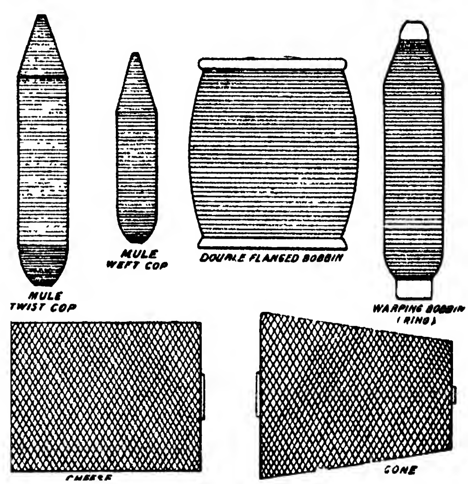
Marking the Warp. In course of its passage out of the slashing machine the warp is measured by the rotations of a roller. The shaft of this roller is in gear with wheels and with a cam which governs the action of a striker rail surmounting a roller charged with moist colour. In accordance with the manner in which the mechanism has been set, this rail descends and presses the warp against the coloured surface, making a *cut* mark at measured intervals. These marks are for the information of the weaver, and they serve to indicate where a *heading* of coloured yarn, to mark the end of one *piece*, is to be woven in. Articles like loin-cloths may need headings at intervals of three or four yards, but ordinarily the cuts are much more distant. It is not economical to make short warps, and it is customary to make them long enough to weave several pieces, or *cuts*.

Other machines are employed instead of the slasher, which is the most advantageous in point of cost, although not in perfection of results. In the *dresser machine*, a type that has been superseded for all purposes except the sizing of the very finest yarns, the ends of warp are separated one from another by passing between the interstices of reeds, and they are dried by the action of heated air. *Ball sizing* is done not so much by manufacturers as by dyers. Ball warps are taken and uncoiled, and, after being opened flat and well impregnated with size, are dried upon the cylinders of a separate machine and re-wound into balls or on to a beam.

Yarn can be sized also in the form of hanks, and the usual method is to allow the hanks to absorb size by running them in and out of the liquor, and then by twisting the hanks between hooks, to wring out the surplus and equalise the supply. To prevent the sticking together of adjoining threads, the hanks are next stretched over rollers and mechanically shaken and brushed. After this has been done, the yarn is in readiness to be wound upon bobbins and into warp.

Treatment of Weft Yarn. Weft yarn is not sized, and is wanted in as supple a form as may be. It has already been said that weft is usually delivered from the spinner in a condition ready for the shuttle. Dyed wefts and some others require, however, to be re-wound, and the machines preferred are those that make a firm and compact core of yarn. There is a time loss in refilling shuttles, and a slight loss also of yarn, so that economy is consulted in using long lengths in the shuttle rather than short ones.

Healding. When the warp has been sized, marked, and beamed, only one operation remains before weaving begins. The threads have to be *drawn-in* [3], or in other words threaded, individually through the eyes or *mails* of the healds or harness used to control the movement of the warp threads in the loom, and also through the *dents* of the loom *reed*. The healds are made either of cord or wire, and their number, which is in no case less than two, varies with the pattern to be woven. Every warp thread in due sequence has to be drawn through one or more of these eyes, the ends are generally led in couples through the openings in the reed. The operation is tedious in the extreme. The number of threads to be dealt with varies according to the width and fineness of the cloth, but upon an average is probably 2500. The process is shortened when the new warp can be *twisted in*, or joined to the ends of an old warp. The threads of the old and the new warp are twisted, not tied, together, and this method is followed when the number of threads and the arrangement of healds is alike, and when the *thrums* or ends of the old warp have been left undisturbed in the healds after weaving. The

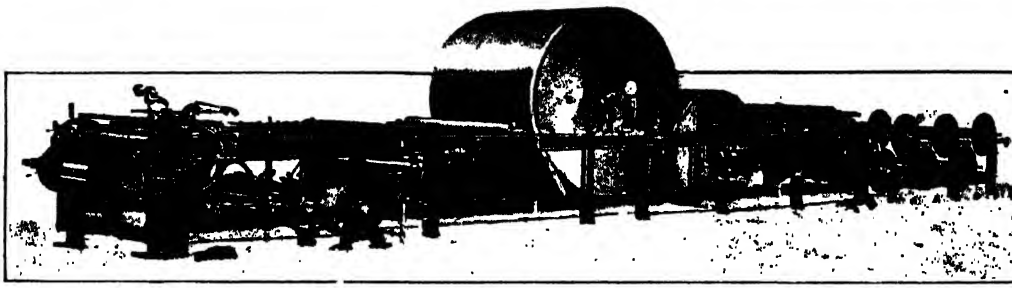


5. COPS, BOBBINS, CHEESE, AND CONE

process of putting new warps into the loom is expensive, and much is added to the cost of weaving if only short warps can be put into the loom.

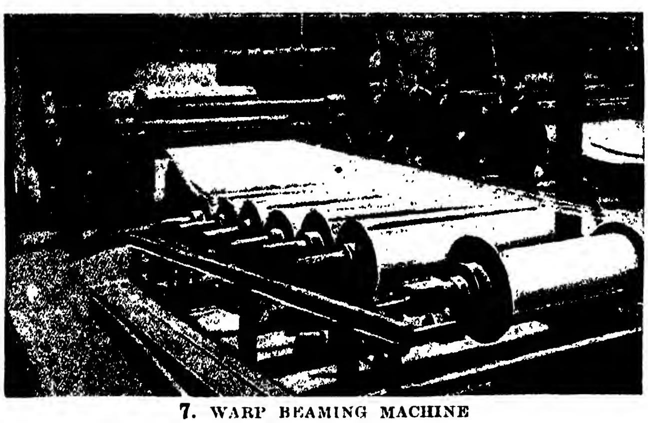
Within the last few years the engineer has succeeded in accomplishing the work of healding by machine

Warp-tying Machines. *Warp-tying machines* are now successfully at work. They are costly, and useful mainly to owners of large plants, but they save labour. The machines tie together the ends of a new warp to those of the old one. The warps are spread in parallel sheets and secured, the old warp at a higher level than the new one. Needles upon the machine select the threads in their proper order, tie them together by making a knot upon each one, and automatically cut off the loose ends. The type of machine made for use with plants of a thousand looms ties about 10,000 knots an hour, and needs only the attention of a man and a boy. A smaller apparatus for sheds of 600 to 700 looms deals with the warp by sections, ties some 6000 ends an hour, and is operated by one man.



6. A SIZING MACHINE
By courtesy of Atherton Bros., Preston

The Importance of a Moist Atmosphere in Weaving. The description of machines in use in the cotton trade has been carried now from the bale to the entry into the loom. As the account has necessarily been complicated by the enumeration of alternative courses, a diagram [4] is given of the sequence of machines ordinarily used in manufacturing plain cotton piece goods. The loom is left for further consideration, and attention may be paid in this place to an important auxiliary in the equipment of a weaving shed. The chemist—William Thomson—showed many years ago that moisture has a great influence upon the strength of cotton thread. The addition of moisture increases the strength a little, and it was found that on adding about 8½ per cent. of moisture, the breaking strain improved some 5 lb. It is the subtraction of normal moisture which tells most upon the strength, and the experiments showed that when a sample was deprived of 6 per cent. of moisture the breaking strain was lowered 24 lb.



7. WARP BEAMING MACHINE
By courtesy of H. Bannerman & Sons, Ltd., Manchester

It is well, therefore, to secure a sufficiently moist atmosphere for weaving, and about half the cotton weaving sheds in this country are fitted with some means of artificial humidification. Moisture is doubly necessary where heavy-sized warps are woven, for in dry air the crust or size is brittle, and the action of weaving produces an unwholesome dust, as well as an avoidable loss of weight. The weather records show how much the natural humidity of the atmosphere varies from day to day, and unless Nature is assisted, weaving is bound to be more difficult on some days than others. The breaking of threads is, of course, bad for the cloth, and the reduced production arising from stoppages lowers both profits and wages.

Legal Requirements Regarding Atmosphere. Wet, steamy air is unhealthy for weavers, and for a quarter of a century the permissible limit of moisture has been regulated by law. The amount of water that air will carry without feeling moist is a matter of temperature. A proportion that makes the atmosphere misty at freezing point means uncomfortably dry air in a room heated to 60 degrees. The quantity is a relative one, and the regulations require that hygrometers, or wet and dry bulb thermometers, to record the relative humidity [see page 1271], shall be hung in every humidified weaving room, and that the reading shall be registered on an official form three times a day.

Humidification is intimately connected with ventilation, and the law lays down rules as to the proportion of carbonic gas that may be present in humidified rooms. The means of obtaining an equable supply of moisture vary from sprinkling the floor with water, blowing steam into the room, or drawing in fresh air through wet sheets, up to more scientific installations. In a system widely employed the air is drawn by a centrifugal blower down a trunk or pipe where it is warmed by steam coils, moistened by passing through a chamber of escaping steam, and finally distributed over the building through zinc gauze. Turbo-humidifiers for dispersing water at high pressure in the form of fine drops are used, and some attempts have been made at localising humidification by moistening the warp during weaving, by a water spray on the loom.

J. A. HUNTER

17. A SILL OF DOLERITE, AN IGNEOUS ROCK, CUTTING ACROSS EDGES OF SEDIMENTARY ROCKS

18. COLUMNS OF BASALT LAVA ON THE SEASHORE NEAR KINGHORN, FIFESHIRE

Classification of Rocks. The Two Great Divisions: Igneous or Crystalline, and Sedimentary or Stratified Rocks.

THE STUDY OF ROCKS

We made acquaintance in the last chapter with the chief minerals of which the rocks of the earth's crust are composed. We have now closely to study those rocks themselves. They are divided into three main classes: *igneous, sedimentary,* and *metamorphic* rocks.

What is a Rock? In the first place, the student must disabuse his mind of the ideas commonly attached to the word *rock*. Ordinary language associates the idea of hardness with a rock. Geology takes no account of such a qualification. If the student looks back to the definition of a rock given in the last chapter he will see that it applies to all the types of matter which are to be found naturally existing in the crust of the earth. The bed of pebbles left on the convex side of a river bend, the great masses of loose sand which compose the sea-beach or the desert of the Sahara, the lumps of coal in the domestic scuttle, the clay and loam in our garden beds, the stone flags of the street pavements, the precipitous granite cliffs of Cornwall and the chalky heights of Beachy Head, are all equally rocks in the geological sense of the word.

There is not even any scientific distinction between a *mineral* and a *rock*. Calcium carbonate is a mineral if we consider a single crystal of Iceland spar, a rock if we go to Carrara and look at the gigantic masses of marble of which the hills are there composed. Salt is a mineral in our salt-cellars, a rock when we think of the great beds of rock-salt which underlie parts of Cheshire. But, as a rule, a rock is composed of more than one mineral, and the study of mineralogy is thus a necessary preliminary to that wider branch of geology which deals with the rocks of which the earth's crust is variously built up.

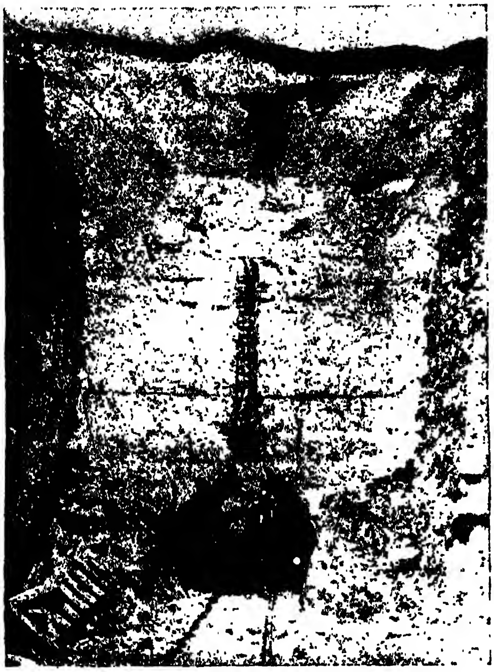
How Rocks are Studied. Rocks differ so widely in character that at first sight it might seem hopeless to devise any method of *classification* which should include them all under any moderate number of heads. The beginner sees little in common between sea-sand and a piece of flint, the columnar basalts of Staffa and the clay of a newly ploughed field, the tailor's French chalk and the coal in the grate. Yet to the geologist these rocks, like all others, present well-marked points of distinction and similarity, according to which they can be arranged in a very small number of classes.

The geologist is guided by various considerations. First comes the *structure* of a rock under examination, as visible to the naked eye (*macroscopic*), or to the eye aided by lenses (*microscopic*). Then the *chemical composition* has to be investigated. Lastly comes the manner in which the *rock-masses* are arranged in Nature. All these ways of looking at rocks afford a clue to their classification, and throw light upon the history of the earth.

The Geologist's Tools. The geologist in the field, armed with such tools as he can conveniently carry, aims chiefly at studying the *macroscopic* characters of the rocks with which he meets. These tools include a geological *hammer*, with its head prolonged into a chisel edge at the back, used for chopping off fragments of rocks, and so finding out what their internal appearance is—this often differs considerably from the appearance of the outside, which has been exposed to all atmospheric changes and has weathered into a modified form. To this hammer, the geologist's chief instrument, he adds a *pocket-lens*, a *knife* with a hard steel blade for scratching rocks, a *magnet*, and a vial of dilute *acid*—usually hydrochloric acid or spirits of salt (HCl). With these instruments he can generally make a rough guess at the nature of any rock which he is likely to meet, and can collect specimens for the more detailed analysis of the laboratory. In addition, he carries a map of the district which he is examining, on the largest convenient scale—the Ordnance Survey sheets, one inch and six inches to the mile, are the best for this country. With the aid of a pocket *compass* and a *clinometer* [59, page 719], or instrument for measuring slopes, he can orient himself in the field and calculate the *dip*, or angle, at which the beds of rock are inclined to the level surface. We shall see later on how these latter instruments are used; they belong to the wider study of *geotectonics*, or the fashion in which the crust is built up of the rocks which we have first to question of their individual structure.

Classification of Rocks. The *system of classification* of rocks now universally adopted depends upon a natural distinction between the ways in which the two main classes of rocks came into existence. This has been worked out by the labour of several generations of patient students of the rocks, both in small specimens and in the great masses of Nature. We can but give here the briefest sketch of the conclusions which were thus reached.

Crystalline and Non-Crystalline Rocks. If the student has access to any small collection of rock specimens, he will speedily notice one great distinction between them. Some of them show a distinct *crystalline* structure—that is, they consist of well-marked crystals of all sorts and sizes, held together by a more or less abundant cement or paste. Ordinary granite [20] affords an admirable example. Other rocks, again, have no such structure, but consist of *non-crystalline* particles held together by a cement, or



19. CHALK PIT SHOWING STRATIFICATION

packed so closely as to adhere by their own cohesion. Sandstone, flint, and conglomerate or pudding-stone afford good instances. Sometimes the crystals of which a rock is composed are so tiny that they can only be recognised by a microscope. But it is generally safe to say that any given specimen of rock is either crystalline or non-crystalline, and this distinction affords us the first possibilty of classification.

Stratified and Unstratified Rocks. The second principle of rock classification must be studied in the field. If the student will visit a quarry or railway cutting, where he can see below the normal surface of the ground, he will soon notice a well-marked difference between various kinds of rocks. Some rocks are always arranged in distinct layers or beds parallel to one another—though not necessarily parallel to the surface of the ground—which are known as *strata*. These may be compared to the bricks in the work of a house. These strata [19] may be seen in a chalk pit, or where the railway runs through banks of sandstone, or on the seashore in the face of the cliffs along the greater part of the South Coast. But they will be vainly sought in a granite or marble quarry, or where the sea breaks, as in Cornwall or North-east Scotland, against precipices of living granite. The existence or non-existence of these layers in a rock affords another basis of classification into *stratified* and *unstratified* rocks.

Fossiliferous and Non-Fossiliferous Rocks. The third line on which we may draw our classification is that of the presence or absence of organic relics or *fossils* in a rock. Some rocks, like chalk and coal, are composed almost entirely of such organic remains, though they may, as in chalk, be only visible through a microscope, or, as in coal, be so thoroughly altered that their organic nature is only evident in exceptional cases. It is on the skeletons and bones, shells and teeth [22], and other hard portions of the anatomy of extinct animals thus preserved in the heart of the rocks that we depend for nearly all our knowledge of the history of life upon the earth. We shall see later how they came there. Just now it is enough to observe that it is only in certain kinds of rock that these fossils are ever found, and so we may make a third distinction between *fossiliferous* and *non-fossiliferous* rocks.

Now, if we study all the rock specimens that we can obtain in the light of these three different principles, a very curious and interesting fact emerges from obscurity. The three methods of classification all lead to the same result. With certain exceptions, which have led to the establishment of a third intermediate class, we find that a rock which is crystalline is also unstratified, and contains no fossils or relics of organic life.

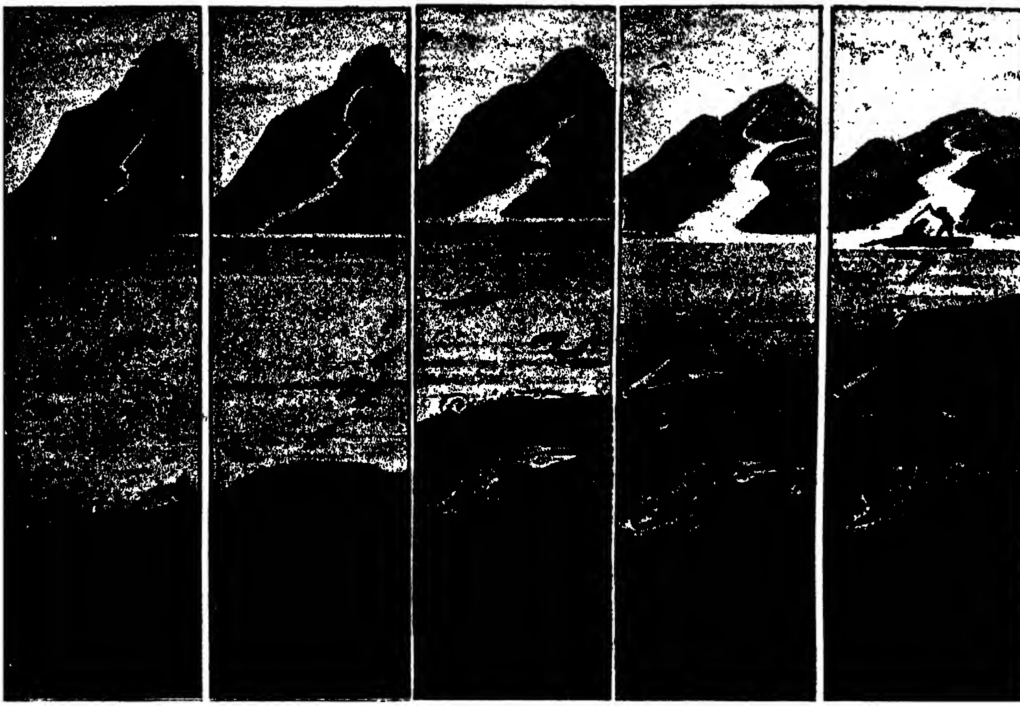
A stratified rock is almost always non-crystalline, though there are exceptions to this rule, which we shall encounter later, and we may expect to find organic remains in it, though it must be understood that by no means all stratified rocks are fossiliferous. Lastly, if we find a tiny specimen of rock which contains a fossil, we may predict almost with certainty that the rock from which it came is non-crystalline in structure, and arranged in layers or strata. Thus, we have now arrived at two great main classes into which rocks may be divided :

1. Crystalline, unstratified, non-fossiliferous.
2. Non-crystalline, stratified, fossiliferous.

Igneous Rocks. The names usually given to these families are derived from a consideration of the manner in which they were formed. This is not difficult, even for the beginner, to perceive.

20. GRANITE BANDS IN SLATES, CORNWALL

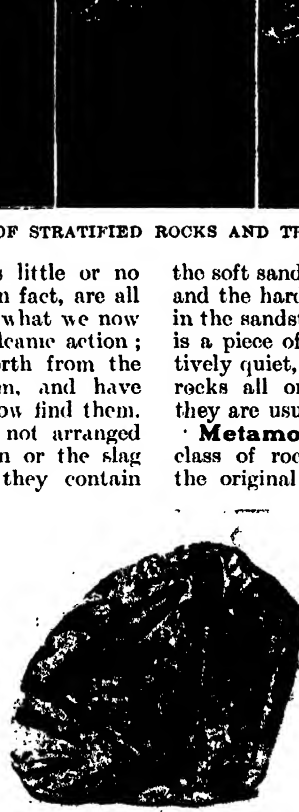
Crystals are formed when a body which has been molten or dissolved solidifies. Consequently we say at once that the first class, or crystalline rocks, must once have been molten, because the



21. THE LAYING DOWN OF STRATIFIED ROCKS AND THE IMBEDDING OF FOSSILS

only possible solvent (water) has little or no action upon them. These rocks, in fact, are all the product of something akin to what we now know in a degenerate form as volcanic action; they must have been poured forth from the earth's interior in a liquid form, and have solidified in the place where we now find them. This also explains why they are not arranged in strata, any more than pig-iron or the slag of the blast furnace, and why they contain no relics of organic life. These rocks, then, are usually called *igneous*, as having their origin in fire, or *eruptive*. We shall use the former term [18].

Sedimentary Rocks. The stratified rocks must have been produced in a different fashion. We can see how it was if we take a slab of sandstone, with its distinct beds or layers, and compare it with the sand of the sea-shore. The only way in which sand can be arranged in regular strata is by the action of water. The winds and tides churn it up till it floats for a while, then it gradually settles down and is deposited as a layer or stratum on the ocean bed [21]. Another layer is deposited on that, and then another, till the first layers have sunk so far that the pressure of the sand and the ocean above consolidates them into a soft kind of rock. Meantime, the living creatures in the sea have been dying and sinking down into the soft sand, where their perishable part decays and the hard part is left, to reappear as a fossil in the sandstone of a future age. Wherever there is a piece of water that is sometimes comparatively quiet, this action must go on. As stratified rocks all originate from hardened sediments, they are usually called *sedimentary* [17].



22. CUTTLEFISH BONES IN A ROCK

Metamorphic Rocks. There is a third class of rocks, which is due to the fact that the original formations have been altered by various agencies. Sedimentary rocks may have been baked or even melted by later heat, like marble, which is merely limestone crystallised in solidifying under pressure. Igneous rocks may have obtained a falsely stratified structure, in consequence of pressure. Thus we find many rocks, the Gneisses and Schists being the best examples, which seem to form a class intermediate between the other two. These are called *metamorphic* rocks, because they have been *metamorphosed* or changed from their original nature. The igneous rocks are the oldest. The sedimentary rocks were formed from them by their gradual attrition to dust by natural processes of weathering, and the new manufacture of this dust into sedimentary rocks by water. Thus the igneous rocks are also called *primitive*, and the sedimentary and metamorphic rocks *secondary* or *derivative*. W. E. GARRETT FISHER

Waterflow and Discharge. Measuring Velocity of Flowing Water. Effect of Friction upon Velocity and Discharge. Weirs.

UTILISATION OF RUNNING WATER

Discharge through Orifices. On page 1435 it was stated that the pressure of a liquid against a surface acts always perpendicularly to that surface. So that in **116**, if a hole were made in the side of the vessel at A, the contained liquid would issue therefrom at right angles, the parabolic curve which it forms being due to the action of gravity on the particles of the liquid after leaving the orifice. The height, BA, of the surface of water above the centre of the orifice is termed the *head*, and it is self-evident that increase of head means increase of pressure at the orifice, and consequent increase in the discharge. Now, whenever a liquid is discharged from an opening in a thin plate, as in the illustration, the issuing stream becomes contracted just outside the orifice, forming at this point what is known as the *vena contracta*, or *contracted vein*. Its position, indicated by the arrow, lies always at a distance from the opening equal to half the diameter of the orifice, and its area is ·64 times (approximately $\frac{2}{3}$) that of the orifice. Hence the quantity ·64 is termed the *coefficient of contraction*. Theoretically, the velocity with which the water would be discharged at A is equal to the velocity of a body falling, under the influence of gravity, from B to A—that is, through a distance equal to the head, H, of the water—and this velocity is shown by the familiar formula, $V = \sqrt{2gH}$, where V = velocity in feet per second, g = the acceleration due to gravity, or 32·2, and H = the head. By substituting the value of g, the formula may be simplified:

$$V = \sqrt{2 \times 32{\cdot}2 \times H} = \sqrt{64{\cdot}4 \times H} = 8{\cdot}03 \times \sqrt{H}.$$

The *theoretical velocity* may thus be found with sufficient accuracy by multiplying the square root of the head of depth of water by 8. Conversely, the *theoretical head* necessary for a given velocity is got by putting H on the left-hand side of the equation:

$$\sqrt{H} = \frac{V}{8} \quad \text{or} \quad H = \frac{V^2}{64}$$

Friction Lessens Velocity. As the italics in the preceding lines suggest, a jet of water issuing from an orifice does not possess the velocity which theory is prepared to give it. As soon as the particles of water in the interior of a vessel approach the orifice, they converge as indicated in **116**. This convergence and the subsequent contraction, which reaches its limit in the vena contracta, give rise to considerable friction between the particles, and so neither the actual velocity nor discharge equals the theoretical total. Hence the value of V in the above equations has to be diminished by multiplying it by certain decimal quantities (coefficients of discharge), according to the shape of the orifice. In discharges through a hole in a thin plate, as in the diagram [**116**], the *coefficient of velocity* is ·97, so that the corrected equation becomes

$$V = 8 \times {\cdot}97\ \sqrt{H}.$$

Velocity and Discharge. So, too, with the discharge. Theoretically, this would be the product of the theoretical velocity in feet per second and of the area of the orifice in square feet. Actually, the discharge is much less, for the velocity must be multiplied by the coefficient ·97, and the area of orifice by ·64. Therefore, if A = the area of orifice in square feet, Q the number of cubic feet of water discharged per second,

$$Q = {\cdot}64 \times A \times {\cdot}97 \times \text{theor. vel.}$$
$$= {\cdot}64 \times A \times {\cdot}97 \times \sqrt{2gH}$$
$$= A \times {\cdot}62 \times \sqrt{2gH}.$$

This quantity ·62, the product of the coefficients of contraction and velocity, is called the *coefficient of discharge*.

Substituting the value of g,

$$Q = {\cdot}62 \times A \times \sqrt{2 \times 32 \times H},$$
$$= {\cdot}62 \times A \times 8 \times \sqrt{H},$$
$$= 4{\cdot}96 \times A \times \sqrt{H}.$$

So that for all practical purposes the formula for calculating the *actual* discharge through a circular orifice in a thin plate becomes

$$Q = 5 \times A \times \sqrt{H}.$$

Partly to bridge over this considerable gulf between actual and theoretical discharge, experiments have been carried out with variously shaped orifices, and the result has been to make the actual more nearly approach the theoretical discharge. It is found, for example, that if the opening be in the form of a short tube [C, in **116**], the length of which is two and a half to three times its diameter, the flow is greatly increased, and the coefficient of discharge is about ·81. Hence,

$$Q = {\cdot}81 \times A \times 8 \times \sqrt{H},$$
$$= 6{\cdot}48 \times A \times \sqrt{H}.$$

If the walls of the vessel or reservoir be thick [A, **117**], so that the ratio between the length and diameter of the opening mentioned above holds good, the discharge is the same as with a short tube. But if the opening or short tube projects into the interior of the vessel the flow is less, the coefficient being about ·70. On the other hand, if the opening or tube be shaped as at B in **117**, the discharge barely falls short of the theoretical amount, the coefficient being as high as ·96 with only a moderate head.

C and D [**118**] are other forms of orifices with coefficients of discharge of over ·90, and these in various guises are the forms used for

the outlets of tanks. If the length of the opening be less than twice its diameter, contraction takes place as at A [116], and the discharge is lessened. If the tube be lengthened beyond four times its diameter, the discharge is also decreased, so that with a tube whose length is equal to six times the diameter, the coefficient of discharge is ·76; 30 times the diameter, ·65; 70 times, ·55; 100 times, ·48; in which case the openings come under the head of pipes.

Flow of Water in Pipes. Thus, in long pipes the actual discharge falls very considerably below the theoretical, so that to attain a given velocity or discharge a much greater head is required than would be expected. The total head is used up in three ways—in overcoming frictional resistance to flow within the pipe, in overcoming the resistance at the entrance of the pipe, and in maintaining the velocity of the water. In long pipes, the loss of head due to friction is so great in proportion that velocity and entry heads are neglected. The friction head may be calculated by Weisbach's formula:

$$\text{Friction head} = \left(\cdot 0144 + \frac{\cdot 01716}{\sqrt{\text{vel. in ft. per sec.}}} \right) \times \frac{\text{length in ft.}}{\text{diam. in ft.}} \times \frac{\text{vel.}^2 \text{ in ft. per sec.}}{64 \cdot 4}.$$

The entry and velocity heads together never exceed a foot, save in short pipes.

Yet another loss of head in pipes is that due to bends necessitated by a change in direction. If the bend be not very sharp and be in form an arc of a circle [119] (as opposed to a knee, elbow, or angular bend), the additional head required is not very great; it may be calculated from the following formula:

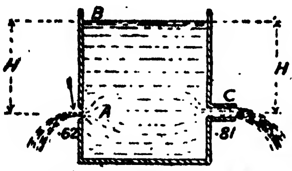
$$H = \cdot 131 + 1 \cdot 847 \left(\frac{r}{R} \right) \times \frac{\;}{64 \cdot 4} \times \frac{r}{180},$$

in which H is the additional head in feet, *r* [119] the radius of the bore of the pipe in feet, R the radius of the centre line of the bend in feet, ϕ, the central angle (at A) in degrees, V the velocity in feet per second. To maintain the velocity which a straight pipe would have given, this additional head, consumed in passing the bend, must be added to the previously calculated total head.

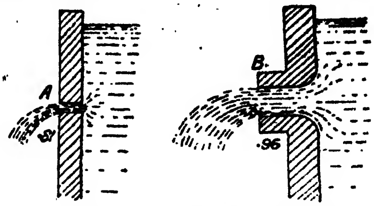
The Piezometer. The great loss of energy shown by gradually diminished pressure in a line of pipes is strikingly shown by an instrument called a *piezometer* (Gr. *piezo*, I press; *metron*, a measure), or pressure-measurer. The principle on which it acts is shown in **120**. If a hole be pierced in the vessel at F, a jet of water immediately springs upwards, reaching a certain height before it falls. Theoretically, as was stated in the early part of this article, it leaves the vessel at F with the same velocity which it would have acquired in falling through the distance H, and hence the jet should reach the level of the water in the vessel before falling. It fails to attain this height, partly because of the retarding influence of the atmosphere, and partly because it is hindered by the falling particles of water. It follows, therefore, that if an open tube were inserted at any point in a main, water would rise in the tube to a height equal to the head for the pressure at that point. The piezometer is a tube adapted to this particular purpose. In addition to its use in gauging pressure at any point, it is of great value in locating obstructions. If at any point water fails to rise in the piezometer to the height it should, it is known that the obstruction lies between the instrument and the head, but if the height registered be greater than it should, the obstruction lies in the opposite direction. By repeated experiment it is finally located.

Piezometers in Series. A series of piezometers applied to a long main, as in **121**, would reveal a steadily diminishing pressure, as shown by the successive decrease in the heights of the columns *a*, *b*, *c*, *d*, *e*. A line, *x*-*y*, joining these levels, is termed the *hydraulic mean gradient*, or *hydraulic grade line*. A little consideration will show that such a line in a scale diagram reveals a good deal of useful information, showing, as it does, the loss due to friction or other causes from point to point. In pipes of uniform bore throughout, the gradient becomes a straight line, as in the diagram, from *x* to *y*, and as long as they lie below this line it does not matter whether, in following the contour of the ground, the pipes slope up or down. The two pipes A and B in **122** will discharge equal quantities of water with the same velocity, because they are equal in length and bore, and *have the same head*, H; yet it might be thought that because B is inclined upwards water would rise in it with less velocity than it descends A. Where frictional or other resistances occur abruptly, as when the pipes are of different diameters, the hydraulic grade line is not straight, as in **121**, for each pipe would have its own gradient.

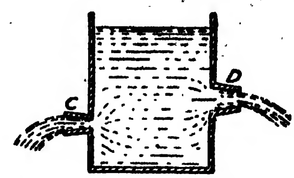
Principle of the Syphon. Before leaving the question of the flow of water through pipes, it will be of interest to refer to the principle of the syphon, a principle the application of which is of practical value in the drainage of accumulations of water to lower levels, when the pipes have to rise to a higher level than that of the surface of the water. A pipe, or, for experimental purposes, a piece of glass tubing, is bent as in **123**. The tube is filled with water, and both openings are closed until the end A is placed in the liquid; or A may be placed below the surface and suction applied at the opening B, until the contained air is withdrawn and both legs are filled with water. A stream of water then commences to flow through the syphon up the short leg, AC, and down and out of the longer leg, CB. Now, the pressure of the atmosphere on the surface of the water in the right-hand tank or reservoir is the same as that on the left hand, and these equal pressures may be considered as being transmitted upwards through the legs of the tube, tending to force the water in AC down CB, and vice versâ. These air pressures, then, are equal, but the pressures at the ends of the tube due to the vertical head of water are unequal. Thus, in the longer leg, CB, the water has a head, H, as compared



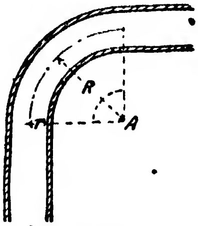
116. FLOW OF WATER THROUGH ORIFICES



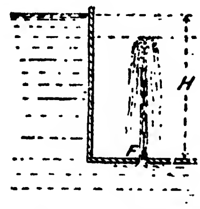
117. DISCHARGE OF WATER THROUGH THICK TUBES



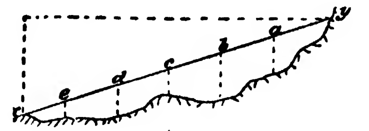
118. WATER DISCHARGE BY TAPERED ORIFICES



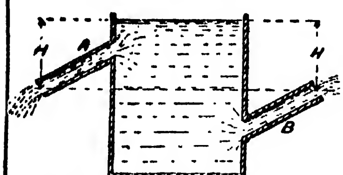
119. WATERFLOW IN WIDE BEND PIPE



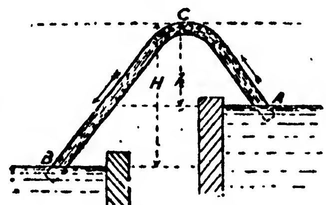
120. PIEZOMETER



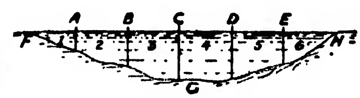
121. SERIES OF PIEZOMETERS



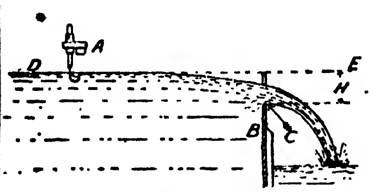
122. INSTANCE OF EQUAL WATER DISCHARGE



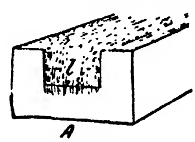
123. THE SYPHON



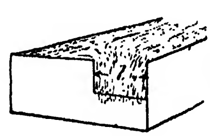
124. DIVISION OF STREAM FOR VELOCITY MEASUREMENT



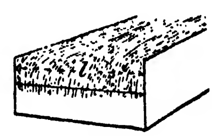
125. WEIR



126



127



128

WATERFLOW OVER A WEIR

116–128. THE HYDROSTATICS OF RUNNING WATER

with a head, h, in the shorter leg. There is, therefore, a difference of pressure, $H - h$, and consequently a flow commences through the syphon; for, as the water descends the long arm, a vacuum would be produced at C did not the water in the reservoir rise through A to fill its place (owing to the atmospheric pressure on the water surface). A continuous flow thus sets in until $H = h$; that is, the heads become equal, and the surfaces in the two vessels reach the same level, or the upper reservoir is drained.

Limitations of the Syphon. It has just been stated that the water rises to C (to fill the space left by the descending stream) because of the pressure of the atmosphere. Therefore, it follows that the syphon will cease working when the point C is higher than 34 ft. above the water level, for the pressure of the atmosphere is unable to support a column of water of greater height. As a matter of fact, it should be less, for in practice it is found that in drainage on the syphon principle the highest point reached by the pipes must never even attain 30 ft. above the surface of the water drained.

Measuring the Velocity of a Stream. It is sometimes required to measure the velocity of the water in a stream for engineering purposes, and this is a matter of greater difficulty than would be imagined. It is clear that in the case of a stream, as in orifices, pipes, etc.,

$$\text{Vol.} = \text{mean velocity} \times \text{cross-sectional area.}$$

$$\text{Mean velocity} = \frac{\text{volume}}{\text{cross-sectional area}}.$$

But the great difficulty lies in estimating the mean velocity, for the rate of flow varies in all parts of the stream. Velocity is greatest in the middle of a stream, and a little below the surface, at a distance equal to about a third of the total depth. In shallow streams this point is found nearer to, and in very deep streams farther from, the surface. Velocity decreases as the banks are neared, while on the bed of the stream it falls to the minimum. How, then, shall the mean velocity be ascertained? As a result of long and careful experiments, it has been found that the mean velocity of a stream is approximately 84 per cent. of the maximum velocity found at or near the surface in the centre part of the stream, while the bottom velocity varies between 50 and 75 per cent. of the mean. The following is, then, a ready means of roughly reckoning the average velocity of a stream. Choose a portion of the watercourse where the velocity is fairly uniform, and measure off a certain distance—say, 60–150 ft. On a day when it is not windy a small float of wood is placed in the centre of the stream, and the time it takes in floating along the marked course is carefully noted; or a corked bottle is often preferred. If, for instance, it travelled 72 ft in 18 seconds, its velocity would be 72/18 = 4 ft. per second. Then, 84 per cent. of this maximum surface velocity equals 4 × ·84 = 3·36 ft. per second = mean velocity of the stream.

A More Exact Method. For greater exactness, and for finding the cross-sectional area, a stream is divided into sections, 1, 2, 3, 4, 5, 6 [124], by means of upright poles, A, B, C, D, E, placed at equal distances apart. The depth of each portion is then taken (midway between each pair of poles), and the average depth thus found; this, multiplied by the width, gives the area of the cross-section. To obtain the average velocity of the whole, each section is dealt with separately, its mean velocity in feet per second being ascertained by a long float weighted at the bottom, so that it swims vertically, or nearly so. When each section has been thus dealt with, the average velocity for the whole of the section, multiplied by the area of the cross-section in square feet, gives the volume or discharge in cubic feet per second.

Weirs. The methods of calculating the flow of water just described apply only to large rivers or canals; in the case of a small stream the quantity of water available for water-wheels or other purposes is best calculated by means of a weir. In **125**, B is a thin plate in which is a gauge notch over which the water falls. Knowing the length of this notch and the head of water, the quantity of water flowing over the weir may be found. The length of the notch may be easily measured, but the head is not so easily determined. The head is really the distance from the point C (called the crest) to the horizontal line DE, which marks the surface level of the stream before the velocity of approach produces a sloping surface and a lowering of the level. In the diagram, H represents the theoretical head, and at this point the water would be still and the surface horizontal. In practice, however, the head is often measured only a few feet from the weir. This is done by means of an instrument called a *hook gauge* [A, **125**], which consists of a round rod sliding up and down in a tube fixed to a support. At the bottom of the rod is a sharp-pointed wire, in shape like a fish-hook. The tube bears a vernier and the rod a scale, so that very minute fractions of an inch can be measured. The hook is first lowered well below the surface, and then very gradually raised until its point produces a slight prominence as the surface water flows over it. The head is then estimated from the reading of the scale. Another method in which a rule is employed is illustrated in the next article.

Calculating Flow Over a Weir. Having determined the head of water and length of weir, the discharge is found from the formula

$$Q = mlH\ \sqrt{2gH}.$$

Q is the discharge in cubic feet per second; l the length of weir in feet; H the head in feet; g the acceleration of gravity; m a coefficient which varies with the head, but may be taken approximately as ·41. Another formula gives the discharge as

$$Q = 3{\cdot}33\ \left(l - n\ \frac{H}{10}\right)\ H^{\frac{3}{2}}.$$

Here, n is the number of "end contractions" of the weir. End contraction in a stream occurs when the weir is not the full width of the channel. Thus, in **126**, with a weir shaped as at A, the stream lines will take the direction as shown in the plan at B, so that the actual length of the overflow, C–D, is less than the length of the weir l. In **126** there are, therefore, two end contractions; in **127** only one. In **128**, where the weir is the width of the channel, there is no end contraction. Each contraction thus lessens the effective length of the weir to such an extent that $\frac{1}{10}$ of the head, H, must be deducted from the length, l, for each end contraction. In cases such as that in **128** it is evident that $n = 0$, and the formula would then be:

$$Q = 3{\cdot}33\ lH^{\frac{3}{2}}$$

$$\text{or, } Q = 3{\cdot}33\ lH\sqrt{H}.$$

Difficulty of Avoiding Errors. Yet, after the most painstaking observations and the nicest mathematical calculation, the final result is often nothing more than an approximation to the actual discharge. Disregarded, apparent trifles may involve big errors. Thus, a thick crest increases the amount of friction, and so gives a less discharge than a thin plate. A rounded crest allows a greater discharge than a sharp-edged one. Convergence of the banks towards the weir has a similar effect, while the slope of the weir itself aids or hinders the discharge, according to whether it be inclined down-stream or up-stream. All these, and perhaps other unsuspected disturbing influences, combine to render calculated discharges, heads, etc., further from the truth than the student would expect. J. G. HORNER

Spanish: Verb, Position of Pronouns, Telling the Time.
French: The Numerals. German: The Attributive Adjective.

SPANISH Continued from page 1843 By José Plá Cárceles B.A.

Future Indicative. The future indicative of regular verbs is formed by adding to the *infinitive* of each conjugation the terminations *é, ás, á, emos, éis, án.*

Future Indicative of *Comprar*

Singular	*Plural*
comprar-é, I shall buy	*comprar-emos,* we shall buy
comprar-ás	*comprar-éis*
comprar-á	*comprar-án*

Similarly:

Second Conjugation: *beber-é, beber-ás,* etc., I shall drink.

Third Conjugation: *cumplir-é, cumplir-ás,* etc., I shall fulfil.

The future indicative of *ser* and *estar,* being regular, is formed in the same way.—*ser-é, ser-ás,* etc., I shall be; *estar-é, estar-ás,* etc., I shall be.

Haber and *tener* form their future by affixing the above terminations to *habr-* and *tendr-*.—*habr-é, habr-ás,* etc., I shall have; *tendr-é, tendr-ás,* etc., I shall have.

Exercise XXII

to hand over	*entregar*	receipt	*recibo*
to cancel	*cancelar*	account	*cuenta*
to import	*importar*	tool	*herramienta*
to see	*ver*	traveller	*viajante*
to ship	*embarcar*	time	*tiempo*
to build	*construir*	cattle	*ganado*
to issue	*emitir*	Government	*Gobierno*
to mature	*vencer*	road	*carretera*
to translate	*traducir*	bridge	*puente*
to learn	*aprender*	one thousand	*mil*
share	*acción*	December	*Diciembre*

documents, *documentos* then, *entonces*
United States, *Estados Unidos*
railway company, *compañía de ferrocarriles*
bill (of exchange), *letra* (*de cambio*)
next month, *el mes que viene* (lit. the month which is coming)

1. He will hand over the receipts. 2. They will not cancel their account until the spring. 3. Will you import all the tools from the United States? 4. We shall not see the traveller this year. 5. Our agents will ship the cattle as soon as possible. 6. The Government will build new bridges and roads. 7. The railway company will issue one thousand shares. 8. Will you be there very early? 9. The bill will mature in December. 10. Who will translate those German documents? 11. I shall have more time next month. 12. Then I shall have learnt (the) Spanish.

Accusative and Dative of Personal Pronouns. The dative and accusative cases of personal pronouns [see page 778] have two forms, one of which is never preceded by a preposition, and the other always. Both forms are sometimes used in the same sentence (1) to increase the emphasis of the direct or indirect object of the verb, or (2) to avoid ambiguity when the pronouns happen to be the same for both genders, as is the case with the third person. The single form must always be used; the form with *á* can only be employed in connection with the other, but never by itself. These forms are:

	Dative	*Accusative*
me, to me	*me, á mí*	*me, á mí*
thee, to thee	*te, á tí*	*te, á tí*
him, to him	*le, á él*	*le, lo, á él*
her, to her	*le, á ella*	*la, á ella*
us, to us	*nos, á nosotros*	*nos, á nosotros*
you, to you	*os, á vosotros*	*os, á vosotros*
them, to them	*les, á ellos,*	*los, á ellos*
them, to them	*les, á ellas*	*las, á ellas*

Personal Pronouns in other Cases. The other cases of the declension of personal pronouns are formed by the words *mí, tí, él, ella, nosotros, as, vosotros, as, ellos, ellas,* preceded by the corresponding prepositions as in English.—*de mí,* from me; *contra ellos,* against them. "With me," "with thee" are always translated by *conmigo, contigo;* and "with him," "with her" are sometimes rendered by *consigo.*

Rules for the Use and Position of Pronouns. The pronouns *me, te, le, lo, la, nos, os, les, los, las,* called Conjunctive Personal Pronouns, are usually placed in front of the verb whose object they are.—*yo lo envidio,* I envy him.

The pronouns corresponding to the polite forms, *Vd, Vds,* are those of the third person, the masculine or feminine forms being used according to the sex and number of the person or persons addressed.—*yo le he hablado á Vd,* I have spoken to you; *el las ha visto á Vds,* he has seen you (fem. pl.). *A Vd, á Vds* must always be added after the verb for the sake of clearness. As all Spanish nouns are either masculine or feminine, the pronoun "it" and its plural "them" must be rendered by the words corresponding to "him," "her," "them," according to the gender and number of the substantive they stand for.—*yo lo tengo,* I have it; *ella las compraba,* she used to buy them (fem.).

When two pronouns occur in a sentence as direct and indirect objects of the same verb, the indirect (dative) is invariably placed in front of the direct (accusative), and both precede the verb.—*el me lo da,* he gives it to me.

When both pronouns belong to the third person, *se* is used instead of the dative *le, les,* for the sake of euphony.—*yo se lo he enviado,* I have sent it to him.

The word "it," meaning "that," is invariably translated by *lo.*—*yo se lo he explicado,* I have explained it to him.

When *á él, á ella,* etc., are used in order to make the meaning of a sentence quite clear, these words are generally placed after the verb. —*se lo hemos pagado á ella,* we have paid it to her.

In negative sentences personal pronouns are placed between the negative and the verb.—*yo no los veo ahora,* I do not see them now.

When one or two pronouns are used in connection with an infinite or present participle, they form one word with the verb, to which they are affixed without altering the stress.—*escribirles,* to write to them; *ofreciéndomelo,* offering it to me. Although the pronouns may also be affixed to other tenses, this construction is only met with in literature, never in ordinary conversation.—*prestábaselo con frecuencia,* he used to lend it to them often.

Exercise XXIII

to bring	*traer*	to explain	*explicar*
to know	*saber*	to work	*trabajar*
to send	*enviar*	news	*noticias*
to check	*comprobar*	for	*para*
to wish	*desear*	every day	*todos los días*
to give	*dar*	where from ?	*¿ de donde ?*
to lend	*prestar*	mother	*madre*
to speak	*hablar*	policeman	*policía*
to keep	*guardar*	at once	*enseguida*

every other day, *cada dos días*

1. We have no news from him. 2. Is that letter for me ? 3. He had it (f.). 4. Why have you not brought them ? 5. She did not know it. 6. When will you send us the account ? 7. I shall ship them at once. 8. The manager is writing to him, not to them. 9. Will the Government build it ? 10. They used to check them (f.) every other day. 11. We wish to see him. 12. Where do you import them from ? 13. You used to give it to her, but not to him. 14. Who has lent it to you ? 15. Her mother will not see her next month. 16. We were speaking to them. 17. Was it you who used to hand them over to them every day ? 18. Will they keep the shares or will they sell them ? 19. His friend used to work with me. 20. It will be easier to translate it here. 21. The policeman was explaining it to me.

Telling the Time. The hours of the day are expressed by placing the feminine article *la* in front of the word *una* for "one o'clock," and *las* in front of the cardinal numbers corresponding to the other hours. *Una,* and not *uno,* is used, because the omitted word *hora* is feminine, but none of the other cardinal numbers have gender. —*las ocho,* eight o'clock. In sentences expressing time, "it is," "it was," "it will be," and so on are invariably rendered by *es, era, será,* and so on in front of *la una,* and *son, eran, serán,* and so on, before any of the other hours.

"Past" is invariably translated by *y* (and), and "to" by *menos* (less).—*las seis menos cuarto,* a quarter to six; *las doce y cuarto,* a quarter past twelve; *las dos y media,* half-past two; *las tres menos diez,* ten minutes to three.

The cardinal numbers up to twelve are given on page 516.

Exercise XXIV

13. *trece.* 14, *catorce.* 15, *quince.* 16, *dieciseis.* 17, *diecisiete.* 18, *dieciocho.* 19, *diecinueve.* 20, *veinte.*

quarter	*cuarto*	half	*media*
minute	*minuto*	fast	*adelantado*
slow	*atrasado*	always	*siempre*
sharp	*en punto*	to end	*acabar*
week	*semana*	to tell	*decir*
watch	*reloj*	performance	*función*
the time	*la hora*	day	*día*
can you ?	*¿ puede V ?*	soon after	*poco después*

with pleasure, *con mucho gusto*
what time is it ? *¿ qué hora es ?*
the station clock, *el reloj de la estación*

1. Five o'clock. 2. Ten o'clock. 3. A quarter to two 4. Half past one. 5. It was five minutes to eleven. 6. It will be then three o'clock. 7. Sixteen minutes to ten. 8. What time is it ? 9. It is four o'clock. 10. My watch is five minutes fast. 11. The station clock is always slow. 12. I shall be there at ten o'clock sharp. 13. A week has seven days, and a year twelve months. 14. Is it one o'clock already ? 15. Not yet. 16. At what time is dinner ? 17. Soon after seven. 18. At what time will the performance end ? 19. At eight o'clock sharp. 20. Can you tell me the time ? 21. With pleasure; it is ten to ten.

Reading Exercise

El hermoso valle del Guadalquivir, que corre entre dos sierras, está cubierto de naranjales y olivares. Varios arroyos transparentes cruzan la llanada y desembocan en el rio. Cada uno de estos arroyuelos tuvo en otro tiempo su puente; pero apenas si ahora queda uno de cada veinte. Durante dos dias viajamos á lo largo del rio. La comarca que éste riega es muy rica y bella; las llanuras están surcadas por ringlas de olivos y ostentan aldeas y castillos á lo largo de las riberas; las colinas norteñas aparecen cubiertas de bosques umbríos y todas las eminencias lejanas, hacia el sur, verdeantes de trigales. En el Carpio hay un molino morisco, con tres enormes aspas que elevan el agua á gran altura. El paisaje contiguo es muy agradable. En Andújar, dejamos la carretera romana y el rio, trozos de los cuales descubríamos, sin embargo, de cuando en cuando, desde las alturas, y entramos en Sierra Morena, cadena de montañas que separa á Castilla de Andalucía, hecha tan famosa por las guerras de moros y cristianos, como por Cervantes que en ella puso la escena de las aventuras más divertidas de su héroe.

A key to the above reading exercise appears in the next chapter.

Key to Exercise XVIII

1. ¿ De quién es este sombrero ? 2. Mío. 3. ¿ Ha vendido V. sus géneros ó los mios ? 4. No he vendido ni los suyos ni los de V. 5. ¿ Es su casa (de V.) más cara que la nuestra ? 6. No sé, pero la nuestra es carísima. 7. Sus temas son los más cortos pero son dificilísimos. ¿ Como son los de V. ? 8. Los míos son más fáciles que los suyos. 9. No es amigo mío.

10. Una frase suya. 11. Son felicísimos. 12. Afirman que esas equivocaciones no son suyas.

KEY TO EXERCISE XIX

1. Cambiaba todos sus billetes en el correo. 2. Escondía la llave. 3. Alquilaba un automóvil todas las mañanas. 4. Administraban la hacienda mientras el dueño estaba ausente. 5. Los soldados estaban luchando en la cumbre de la montaña. 6. La antigua casa gastaba mucho dinero en anuncios. 7. No estaba en casa ese día. 8. Había estado nevando toda la mañana.

KEY TO EXERCISE XX

1. Comía con mis amigos ingleses. 2. Su caballo corría más que el mío. 3. Ella hacía mi trabajo cuando yo estaba en el Continente. 4. ¿ Era V. el que llamaba á la puerta ? 5. ¿ Quién encendía el fuego en su cuarto (de V.) ? 6. Vendían á precios más bajos. 7. Cosía mucho cuando era jóven. 8. Leíamos cuando llovía.

KEY TO EXERCISE XXI

1. Escribíamos casi todas sus cartas. 2. Los soldados dormían en el campamento. 3. Abría todas las ventanas. 4. Distribuían las ganancias entre los accionistas. 5. Vivíamos cerca del rio. 6. ¿ Quién era el tenedor de libros entonces ? 7. No tenían agentes en París. 8. Venía muy temprano. 9. El profesor corregía sus temas. 10. Recibíamos el correo al amanecer.

FRENCH

Continued from page 1712

By Louis A. Barbé, B.A.

NUMERALS—Continued

IV.—Collective and Approximative Numerals

By the addition of *aine* to certain cardinal numbers, numerals are formed that sometimes indicate a collection, sometimes an approximation.

1. *Huit, huitaine.* *Huitaine* is chiefly used as "a week," in expressions of "time how long," as: *J'ai passé une huitaine de jours à Paris*, I spent a week (or, about a week) in Paris; *remettre à huitaine*, to postpone for a week. As a measure of time, "a week" is *une semaine:* The year has 52 weeks, *l'année a cinquante-deux semaines.*

2. *Neuf, neuvaine.* *Neuvaine* is used only in an ecclesiastical sense in the Catholic Church, and means a novena—*i.e.*, nine days' devotions.

3. *Dix, dizaine* (*x* changed into *z*). *Dizaine* is used approximately, "about ten," except in numeration: *les unités et les dizaines*, units and tens; *une dizaine de francs*, about 10 francs.

4. *Douze, douzaine* (*e* omitted). *Douzaine* is used both collectively and approximatively: *Trois douzaines d'œufs*, three dozen eggs; *il n'y a guère qu'une douzaine de personnes*, there are hardly more than a dozen people.

5. *Quinze, quinzaine.* *Quinzaine* is used for a "fortnight," in the same way as *huitaine* for a "week." It is also approximative: *Une quinzaine de francs*, about 15 francs.

6. *Vingtaine* (20), *trentaine* (30), *quarantaine* (40), *cinquantaine* (50), *soixantaine* (60), *centaine* (100), are used approximatively; *Une vingtaine de lignes*, about 20 lines; *une centaine de pages*, about 100 pages.

7. *Mille* has the collective and approximative form *millier :* *Des milliers de francs*, thousands of francs.

8. Multiplicative numerals are: *une fois, deux fois, trois fois*, etc., once, twice, three times, etc.,

V.—Time

The hour of the day is expressed as follows:

Une heure, one o'clock.

Une heure cinq, five minutes past one.

Une heure et quart / *Une heure un quart* / *Une heure et un quart* } a quarter past one.

Une heure et demie, half-past one.

Deux heures moins vingt-cinq, 25 minutes to two.

Une heure trois quarts / *Deux heures moins un quart* / *Deux heures moins le quart* } a quarter to two.

Midi et demi, half past twelve (noon).

Minuit et demi, half past twelve (night).

The expressions, "a.m." and "p.m." are rendered by *du matin, du soir : de dix heures du matin à dix heures du soir*, from 10 a.m. to 10 p.m.

VI.—Dimension

Dimension may be expressed either attributively (without a verb), or predicatively (with a verb).

To express dimension attributively there are three constructions:

1. In the first the noun is followed by an adjective of dimension agreeing with it in gender and number, then by *de*, and lastly by the numeral and noun of measure: *Un mur haut de trois mètres*, a wall three metres high. The other adjectives used in this way are: *long*, long; *large*, broad; *profond*, deep; *épais*, thick.

2. In the second the noun is followed by *de*, with the numeral and noun of measure, and then by another *de* with an invariable adjective of dimension: *Une table de deux mètres de long*, a table two metres long.

This construction is not used with *profond* or *épais*.

3. In the third, the last word, instead of being an invariable adjective, is a noun of dimension: *longueur, largeur, hauteur, profondeur, épaisseur, diamètre, circonférence*: *Un fossé de deux mètres de profondeur*, a ditch two metres deep.

To express dimension predicatively either *être* or *avoir* may be used.

1. With *être* the verb is followed by an adjective agreeing in gender and number with the subject of the verb, and then by *de* with the numeral and noun of measure: *Cette salle est longue de cinq mètres*, this room is five metres long.

2. With *avoir* there are two constructions. In the first the verb is followed by the numeral

and noun of measure, and then by *de* with a noun of dimension: *Ce mur a dix mètres de longueur*, this wall is ten metres long.

In the second the last word is an invariable adjective of dimension: *Cette maison a uinze mètres de haut*, this house is 15 metres

3. Another construction may also be used, corresponding to the English, as: A height of ten feet, *une hauteur de dix pieds ;* this wall has a thickness of six inches, *ce mur a une épaisseur de six pouces*.

De is used in French, though not in English, after the verb "to be" in the measurement of any number or quantity: The population is 7,500, *la population est de sept mille cinq cents ;* the distance is ten miles, *la distance est de dix milles*.

4. Square measure is expressed by means of the preposition *sur : Une plaine de six milles de long sur six de large*, a plain six miles long by six broad.

Sur is also used with numbers, in the sense of "out of": *Nous avons eu deux beaux jours sur dix*, we have had two fine days out of ten.

VII.—Numerals with "En"

When in a sentence a numeral is used without the noun to which it refers, that noun being understood, the pronoun *en* must be used. Its place is immediately before the verb: You have fifteen francs, I have only ten, *Vous avez quinze francs, je n'en ai que dix*.

VIII.—Numerals with "À"

1. In English, when "place where" is indicated in terms of distance, the preposition "at" is omitted. In French the preposition *à* must be used:

Versailles est à vingt-trois kilomètres de Paris, Versailles is twenty-three kilometres from Paris; *Il demeure à dix milles de Londres*, he lives ten miles from London.

2. Between the same numeral repeated, *à* is used to express combination, or union:

Ils marchent deux à deux, they walk two by two.

3. In scoring, at certain games, *à* is used after a numeral to express equality:

Quinze à, Fifteen all!

IX.—Numerals with "De"

1. *De* is used instead of *que*, for "than" before numerals, when no real comparison is expressed:

Vous avez plus de dix fautes, You have more than 10 mistakes.

2. After a numeral (with a noun expressed or understood), "more than," "less than," are rendered by *de plus, de moins :*

J'ai deux fautes de moins que vous, I have two mistakes less than you; *Vous avez cinq francs de plus que nous*, you have five francs more than we.

3. These two uses of *de* may be combined: *Il a plus de cinq cents volumes de plus que vous*, he has more than 500 volumes more than you.

4. In comparison *de* indicates the measure of excess or of inferiority:

Plus âgé de dix ans, older by ten years.

5. When the substantive to which a numeral refers is represented by the pronoun *en*, placed before the verb, the adjective that follows the numeral must have *de* before it:

Sur mille habitants, il n'y en a pas dix de riches, out of a thousand inhabitants, there are not 10 rich.

Exercise XIII.

1. We have spent about a fortnight in London.
2. I have bought (*acheté*), half a pound of butter and half a dozen eggs.
3. In ninety-seven there are nine tens and seven units.
4. There are about a hundred pages in the copy-book (*cahier*).
5. What time is it? It is ten minutes past four; in five minutes it will be (*sera*), a quarter past four, and in twenty minutes it will be half-past four.
6. This street is half a mile long and fifty feet broad.
7. Our house is more than forty feet high.
8. This table is two metres long by one metre seventy-five centimetres broad.
9. You have three mistakes (*fautes, f.*); I have only one.
10. Dover (*Douvres*), is about (*environ*) twenty-one miles from Calais.
11. The Straits of Dover (*le Pas de Calais*), are more than twenty miles broad.
12. You have earned (*gagné*), more than fifty francs more than we.

Key to Exercise X. (page 1576)

1. Il n'y a pas de grandes maisons dans ce village.
2. Ces grands arbres sont des chênes.
3. Ces enfants sont les fils de cet avocat.
4. Cette maison-ci est plus vieille que cette maison-là.
5. Cet enfant est l'élève le plus appliqué de la classe.
6. Avez-vous parlé à ce monsieur et à ces dames?
7. Pourquoi avez-vous mis mes livres sur cette table?
8. Votre frère a acheté ces chevaux.
9. Ce petit garçon et cette petite fille sont très aimables.
10. Je n'ai pas encore lu ces journaux.
11. Quand ces enfants sont sages leur mère est heureuse.
12. Nos parents sont nos meilleurs amis.
13. Cette demoiselle a les cheveux noirs et les yeux bleus.
14. Le garçon parle à sa mère et sa sœur parle à son père.

Key to Exercise XI. (page 1577)

L'histoire naturelle étudie les plantes, les minéraux et les animaux. Les plantes ou les végétaux composent le règne végétal. Les plantes sont semées sur la terre comme les étoiles dans les cieux. Les minéraux sont des corps dans l'intérieur de la terre. Les métaux

sont des minéraux. Dans l'histoire naturelle les animaux une variété infinie d'êtres vivants passent devant nos yeux. Les espèces d'animaux sont plus nombreuses que les espèces de plantes. Les animaux les plus utiles aux hommes sont les animaux domestiques. Parmi les animaux domestiques il y a les chevaux, les ânes, les bœufs, les vaches, les brebis et les chèvres. Les chevaux sont fiers et fougueux, mais ils sont aussi dociles que courageux. Les chevaux sont plus élégants que les ânes et que les bœufs. Leurs oreilles sont moins longues que les oreilles des ânes. Elles ne sont pas si courtes que les oreilles des bœufs. Il y a des chevaux sauvages. Ils sont plus forts, plus légers, plus nerveux que les chevaux domestiques, mais ils sont moins utiles. Les ânes sont bons, sobres et utiles. Ils sont aussi patients et aussi tranquilles que les chevaux sont fiers, ardents et impétueux. Les chiens sont aussi des animaux domestiques. Il y a des chiens sauvages, mais ils sont féroces. Ils sont aussi féroces que les loups et que les chacals. Les chèvres ne sont pas si utiles aux hommes que les brebis, mais elles sont très utiles. Leur poil est plus rude que la laine des brebis. Elles sont plus fortes, plus légères, plus agiles que les brebis. Elles sont vives, robustes, capricieuses et vagabondes. Parmi les animaux sauvages les lions et les tigres sont les plus féroces et les plus cruels. Les renards sont sauvages aussi, mais ils ne sont pas si féroces que les tigres. Ils sont moins féroces que les chacals. Les lièvres sont sauvages, mais ils ne sont pas nuisibles. Ils sont extrêmement timides. Les écureuils aussi sont de petits animaux fort timides. Ils sont très jolis et très intéressants. Ils mangent des fruits, des amandes, des noisettes et des glands. Il n'y a pas d'écureuils dans les champs. Ils sont dans les bois, sur les arbres comme les oiseaux.

Key to Exercise XII. (page 1712)

1. Trois, cinq, sept, onze, douze, quinze, dix-neuf, vingt et un, vingt-deux, trente, trente et un, quarante-quatre, cinquante-cinq, cinquante-huit, soixante, soixante-neuf, soixante-dix, soixante et onze, quatre-vingts, quatre-vingt-neuf, quatre-vingt-onze, quatre-vingt-dix-neuf, cent, deux cent dix, trois cent cinquante, sept cent quatre-vingt-neuf, neuf cent onze, neuf cent quatre-vingt-dix-neuf, mil deux cent trente-quatre.

2. Premier, deuxième, second, quatrième, cinquième, neuvième, vingtième, vingt et unième, trente-deuxième, quarante-cinquième, cinquante et unième, soixante-sixième, soixante-dixième, soixante et onzième, quatre-vingtième, quatre-vingt-unième, quatre-vingt-neuvième, quatre-vingt-dixième, quatre-vingt-onzième, quatre-vingt-dix-neuvième, centième.

3. Un et un font deux, et deux font quatre, et quatre font huit, et huit font seize, et seize font trente-deux, et trente-deux font soixante-quatre, et soixante-quatre font cent vingt-huit.

4. Deux fois un font deux ; trois fois deux font six ; quatre fois six font vingt-quatre ; cinq fois vingt-quatre font cent vingt.

5. La minute contient soixante secondes.

6. La seconde est la soixantième partie d'une minute.

7. La lumière emploie huit minutes treize secondes à venir du soleil.

8. Dans une heure il y a soixante minutes.

9. Le jour est un espace de vingt-quatre heures.

10. De minuit à midi il y a douze heures.

11. L'année est composée de trois cent soixante-cinq jours et un quart.

12. La semaine a sept jours ; le mois a quelquefois trente et un jours, quelquefois trente jours et quelquefois vingt-huit seulement.

13. Le mois de février, le deuxième mois de l'année, a vingt-huit jours.

14. L'année commence le premier janvier ; elle finit le trente et un décembre.

15. Le mois de décembre est le dernier mois de l'année.

16. La fête de Noel tombe toujours le vingt-cinq décembre.

Continued

GERMAN

Continued from page 1714

By P. G. KONODY and Dr. OSTEN

XXI. The Infinitive Past of the verbs is constructed of the participle past of the verb and the infinitive present of the auxiliary verb haben or sein; for instance: laufen, to run (with sein); loben, to praise (with haben): gelaufen sein; gelobt haben.

XXII. Weak Substantives have only *one* inflection (-en or -n) in the genitive singular, which is retained in all other cases of the singular and plural. To this declension in both numbers belong only substantives of masculine gender. Feminines undergo no alteration in the singular [see VI., 2]. and take the inflection only in the plural. Some neuters also take the weak inflection

Table of Weak Declension

	10.		11.		12.		13.	
S. 1.	der Mensch,	[the] man	der Bote,	the messenger	die Frau,	the woman	die Gabel,	the fork
2.	des Mensch-en,	of [the] „	des Bote-n,	of the „	der Frau,	of the „	der Gabel,	of the „
3.	dem Mensch-en,	to [the] „	dem Bote-n,	to the „	der Frau,	to the „	der Gabel,	to the „
4.	den Mensch-en,	[the] „	den Bote-n,	the „	die Frau,	the „	die Gabel,	the „
Pl. 1.	die Mensch-en,	[the] men	die Bote-n,	the messengers	die Frau-en,	the women	die Gabel-n,	the forks
2.	der Mensch-en,	of [the] „	der Bote-n,	of the „	der Frau-en,	of the „	der Gabel-n,	of the „
3.	den Mensch-en,	to [the] „	den Bote-n,	to the „	den Frau-en,	to the „	den Gabel-n,	to the „
4.	die Mensch-en,	[the] „	die Bote-n,	the „	die Frau-en,	the „	die Gabel-n,	the „

the plural; but having the inflections of strong declensions in the singular, they belong to the group of the *mixed* declension [see V., 1].

1, Substantives ending in -e, -el, -r, take the inflection -n [table above, 11, 13]: der Löwe, the lion, *s.* 2. des Löwe-n; die Schwester, the sister, *pl.* die Schwester-n; die Feder, the pen, *pl.* die Feder-n; etc. All others take -en, except der Herr, the master, gentleman, which adds -n in the singular and -en in the plural: *sing.* 1. der Herr, 2. des Herr-n, 3. dem Herr-n, 4. den Herr-n; *pl.* 1. die Herr-en, 2. der Herr-en, 3. den Herr-en, 4. die Herren.

2. To the weak declension belong all masculine substantives (*a*) ending in -e, except der Käse, the cheese, which takes the strong declension; (*b*) those which have dropped this original final sound (der Hirt[e], the shepherd; der Schütz[e], the rifleman; der Bursch[e], the lad; der Ahn[e], the ancestor, etc.); (*c*) representatives of nationalities, countries, and towns (der Baier, the Bavarian; der Un'gar, the Hungarian; der Pommer, the Pomeranian; der Schotte, the Scotsman; der Kosak', the Cossack; der Russe, the Russian; der Kaffer, the Kaffir; etc.), if the denotation is not derived from nationalities, countries, towns, etc. by the suffix -er (der England-er, the Englishman; der Irländ-er, the Irishman; der London-er; der Berlin-er; der Wien-er, the Viennese; der Schweiz-er, the Swiss, [Schweiz, Switzerland]; der Holländ-er, the Dutchman), all of which take the strong declension; (*d*) many masculine substantives of foreign origin ending in -ant, -at, -et, -ent, -graph, -ik, -ist, -og, -nom, and -oph (der Diamant', the diamond; der Prälat', the prelate; der Komet', the comet; der Patient', the patient; der Geograph', the geographer; der Katholik', the catholic; der Alkoholist', the alcoholist: der Geolog', the geologist; der Astronom', the astronomer; der Philosoph', the philosopher).

3. Most feminine substantives belong to the weak declension. All feminines ending in -el and -er (except die Mutter and die Tochter, which are strong and form the plural by modification of the vowel: die Mütter, die Töchter) take the weak inflection, whilst the masculines and neuters ending in -el and -er take the strong declensive terminations. Examples: die Kugel, the ball, *pl.* 1. die Kugel-n; der Vogel, the bird, *s.* 2. des Vogel-s, *pl.* 1. die Vögel; das Übel, the evil, *s.* 2. des Übel-s, *pl.* 1. die Übel; die Ader, the vein, *pl.* 1. die Ader-n; der Adler, the eagle, *s.* 2. des Adler-s, *pl.* 1. die Adler; das Kloster, the convent, *s.* 2. des Kloster-s, *pl.* 1. die Klöster.

XXIII. To the Mixed Declension [see V., 1] with *strong* inflection in the *singular* and *weak* in the *plural* belong several *masculine* and *neuter* substantives (the feminines take no inflection in the singular). Some of these nouns are:

(*a*) The masculines: der Gevatter, the godfather; der Lorbeer, the laurel; der Muskel, the muscle; der Nerv, the nerve; der Psalm, the psalm; der Sporn, the spur; der Schmerz, the pain, grief; der See, the lake; der Staat, the state; der Stachel, the sting; der Strahl, the ray; der Unterthan, the subject; der Vetter, the cousin; der Zierat, the ornament; der Zins, the rent, the tax; etc. Der Dorn, the thorn, der Mast, the mast, and der Pfau, the peacock, generally take the weak plural with the suffix -en, but may also form the plural by taking the suffix -e: *pl.* 1. die Dorn-en (Dorn-e), die Mast-en (Mast-e), die Pfau-en (Pfau-e).

(*b*) The neuters: das Auge, the eye; das Bett, the bed; das Ende, the end; das Hemd, the shirt; das Leid, the grief; das Ohr, the ear; das Weh, the woe, anguish; and several nouns of foreign origin: das Insekt', the insect; das Statut', the statute; das Juwel', the jewel.

(*c*) Masculines of foreign origin with *unstressed* final syllables ending in -l, -n, -or. For instance: der Kon'sul, the consul; der Dä'mon, the demon; der Dok'tor; der Profes'sor, etc.; *pl.* die Kon'suln, die Dämo'nen, die Dokto'ren, die Professo'ren. Note the change of stress where the plural is formed by the suffix -en. Substantives of foreign origin with the stressed termination -or take the strong declension with the suffix -e in the plural [XVI., 2, *c*] *without* change of stress: der Humor', the humour; der Korridor'; das Meteor', etc.; *pl.* die Humo're, die Korrido're, die Meteo're.

(*d*) The masculines: der Friede (Frieden), the peace, der Funke (Funken), the spark, der Gedanke (Gedanken), the thought, der Glaube (Glauben), the faith, der Haufe (Haufen), the heap, der Name, (Namen), the name, der Same (Samen), the seed, der Schade (Schaden), the damage, der Wille, (Willen), the will are used alternately with both terminations, but the first form always takes the strong declension of the form in brackets: *s.* 1. der Name (or Namen), 2. des Namen-s, 3. dem Namen, 4. den Namen; *pl.* 1, die Namen, etc. Another noun with similar irregular declension is das Herz, the heart, *s.* 2. des Herz-ens, 3. dem Herz-en, 4. das Herz; *pl.* 1. die Herz-en.

XXIV. Compound Tenses of Verbs are formed by the aid of the corresponding auxiliary verbs of tense, haben, sein, and werden.

1. The perfect is formed by the *past participle* of the verb [see XIV.] and the *present imperfect* of its auxiliary verb [see Table A., p. 649].

2. The pluperfect is formed by the *past participle* of the verb [see XIV.] and the *present imperfect* of its auxiliary verb [see Table A., p. 649].

Examples: laufen, to run (strong verb conjugated with sein*), past participle: ge-lauf-en, [see XIV.]; loben, to praise (weak verb conjugated with haben), past participle: ge-lob-t, [see XIV.].

Present indicative of sein: ich bin; subjunctive: ich sei; imperfect indicative: ich war; subjunctive: ich wäre. Present indicative of haben: ich habe; subjunctive: ich habe; imperfect indicative: ich hatte; subjunctive: ich hätte.

	Indicative.	*Subjunctive.*
Perfect*:	ich bin gelaufen, etc.	ich sei gelaufen, etc.
	ich habe gelobt „	ich habe gelobt „
Pluperfect:	ich war gelaufen „	ich wäre gelaufen „
	ich hatte gelobt „	ich hätte gelobt „

* laufen being conjugated with *to be* in German, the literal translation of the German perfect and pluperfect would be: I *am* run, and I *was* run. Note this for all other verbs for which differing auxiliary verbs are used: (ich bin gewesen, I *am* [have] been; ich bin gegangen, I *am*

[have] gone, etc. The rest of the conjugation is easily completed with the help of Table A., p. 649, the past participle remaining unaltered.

3. The first future is formed by the present of the auxiliary verb werden and the present infinitive [IV., 2] of the verb itself.

4. The second future is formed by the present of the auxiliary verb werden and the past infinitive of the verb itself. [Table A. p. 649, and XXI.]

EXAMPLES: Present indicative of werden: ich werde; subjunctive: ich werde. Past participles of laufen and loben: gelaufen and gelobt. Past infinitives of laufen and loben: gelaufen sein, gelobt haben.

	Indicative.	*Subjunctive.*
First future:	ich werde laufen	ich werde laufen
	ich werde loben	ich werde loben
Second future:	ich werde gelaufen sein	ich werde gelaufen sein
	ich werde gelobt haben	ich werde gelobt haben

5. The compound forms of auxiliary verbs are formed with the help of each other. Werden is used for the future tenses of all the three: ich werde sein, haben, werden, and ich werde gewesen sein, gehabt haben, geworden sein; while in the perfect and pluperfect sein is conjugated with itself: ich bin gewesen, and ich war gewesen; haben also with itself: ich habe gehabt, and ich hatte gehabt: and werden with sein: ich bin geworden, and ich war geworden.

6. The past participle of werden—*viz.*, geworden—is only employed where the verb is used independently; when used as an auxiliary verb it casts off the prefix ge- and reads: worden: Er ist Bürgermeister geworden, he has become mayor; but: er ist zum Bürgermeister ernannt worden, he has been *nominated* mayor.

XXV. The PREPOSITIONS [see XV.] which govern alternately the *dative* and the *accusative*, are: an (at, on, upon, by, near); auf (on, upon, in, at, up); hinter (behind, after); in (in, into, at); neben (by, near, by the side of, beside); über (over, above, on, upon, at, about); unter (under, below, among, between); vor (before, ago, since); zwischen (between, betwixt, among).

1. The preposition governs the dative if the sentence answers the question wo? (where?); whilst wohin? (whither, where to?) is answered by the accusative: thus the dative implies a state of rest, the accusative of motion.

EXAMPLES: Das Buch liegt auf (3) dem Tische, the book lies on the table [where? Dative: on the table]. Ich lege das Buch auf (4) den Tisch, I put the book on the table [whither? Accusative: on the table]. Der Käfer kriecht auf (3) dem Tische, the beetle crawls on the table (implying that the beetle is crawling about on the table). Der Käfer kriecht auf (4) den Tisch (implying the act of crawling on to the table).

2. The *dative* and *accusative* of the definite article of the dependent noun is often contracted with the governing preposition. The dative singular, masculine and neuter dem may be contracted with the prepositions bei (3), near, about, with, at; von (3), from, of; zu, to, at, by: bei dem, von dem, zu dem, are contracted into beim, vom, zum.

Zu is also contracted with the dative of the feminine definite article der: zu der = zur.

The preposition durch (4), through, by; um (4), around, about, for; and für (4), for, are contracted with the accusative of the neuter definite article das: durch das, um das, für das, into durchs, ums, fürs.

The prepositions an and in are contracted with the *dative* singular, masculine, and neuter dem: an dem = am, in dem = im.

The prepositions an, auf, hinter, in, über, unter, vor, are contracted with the *accusative* singular neuter das into: ans, aufs, hinters, ins, übers, unters, vors; and hinter, über, unter, vor, with the *dative* and *accusative* masculine dem and den into: hinterm (3), hintern (4); überm (3), übern (4); unterm (3), untern (4); vorm (3), vorn (4).

EXAMPLES: Er war im [in (3) dem] Zimmer, he was in the room [where? *dat.*]. Er ging ins [in (4) das] Zimmer, he went into the room [whither? *accus.*]. Ich ging zum [zu (3) dem] Arzte, I went to the doctor. Ich war beim [bei (3) dem] Arzte, I was at the doctor's. Er lief durchs [durch (4) das] Thor und ums [um (4) das] Dorf, he ran through the gate and around the village. Das Bild hängt unterm [unter (3) dem], überm [über (3) dem] Spiegel, the picture hangs underneath, above, the mirror. Er legte sich aufs [auf (4) das], ins [in (4) das] Gras, he laid [himself] down on (*or*, in) the grass [on what? *accus.*]. Er legte sich im [in (3) dem] Grase nieder, he lay down on the grass [where? *dat.*].

XXVI. The ATTRIBUTIVE ADJECTIVE [see VIII., *a*] agrees in gender, number, and case with the substantive which it qualifies, and may therefore take the weak, the strong, or the mixed declension.

1. When preceded by the definite article [I., p. 648] or by a determining noun of corresponding flective termination, pronoun, etc., the adjective takes the weak declension.

EXAMPLE: gut, good, declined as attributive adjective in:

		der gut-e Vater (*m.*)	die gut-e Mutter (*f.*)	das gut-e Kind (*n.*)
Sing.	1.	der gut-e Vater	die gut-e Mutter	das gut-e Kind
„	2.	des gut-en Vaters	der gut-en Mutter	des gut-en Kindes
„	3.	dem gut-en Vater	der gut-en Mutter	dem gut-en Kinde
„	4.	den gut-en Vater	die gut-e Mutter	das gut-e Kind
Pl.	1.	die gut-en Väter	die gut-en Mütter	die gut-en Kinder
„	2.	der gut-en Väter	der gut-en Mütter	der gut-en Kinder
„	3.	den gut-en Vätern	den gut-en Müttern	den gut-en Kindern
„	4.	die gut-en Väter	die gut-en Mütter	die gut-en Kinder

Sing. 1.	gut-er Vater (*m.*)	gut-e Mutter (*f.*)	gut-es Kind (*n.*)	*Pl.* 1.	gut-e Väter, Mütter, Kinder
„ 2.	gut-en* Vaters	gut-er Mutter	gut-en* Kindes	„ 2.	gut-er Väter, Mütter, Kinder
„ 3.	gut-em Vater	gut-er Mutter	gut-em Kinde	„ 3.	gut-en Vätern, Müttern, Kindern
„ 4.	gut-en Vater	gut-e Mutter	gut-es Kind	„ 4.	gut-e Väter, Mütter, Kinder

(*a*) In this declension the adjectives take the inflection -e in the nominative singular of all genders, and in the accusative singular of the feminine and neuter genders.

(*b*) All other cases take the inflection -en.

2. The adjective takes the inflections of the *strong* declension when it is not preceded by the article or by a determining noun with the inflections of the definite article [see above and V., 3]

*An alternative *strong* masculine and neuter genitive -es (gut-es Vaters, gut-es Kindes) is obsolete and only retained in several idiomatic expressions, and even in these the modern form is preferable.

3. The adjective takes the *mixed* declension when preceded by the indefinite article [See V., 4] or by a determining noun with corresponding declensive terminations. Thus:

Sing. 1.	ein gut-er Vater (*m.*)	eine gut-e Mutter (*f.*)	ein gut-es Kind (*n.*)
„ 2.	eines gut-en Vaters	einer gut-en Mutter	eines gut-en Kindes
„ 3.	einem gut-en Vater	einer gut-en Mutter	einem gut-en Kinde
„ 4.	einen gut-en Vater	eine gut-e Mutter	ein gut-es Kind

In the plural, adjectives take the inflections of the *strong* declension, if unattended [XXVI., 2], or of the weak declension, if attended by the definite article or equivalent nouns.

4. The inflections in the declension of the attributive adjective with the definite, with the indefinite, and without article or corresponding noun [see 1, 2, 3], are summarised below:

	Singular			Plural		
	Masculine	*Feminine*	*Neuter*	*Masculine*	*Feminine*	*Neuter*
1. *nominative*	der ..-e ein ..-er ..-er	die ..-e eine ..-e ..-e	das ..-e ein ..-es ..-es	die ..-en — ..-e	die ..-en — ..-e	die ..-en — ..-e
2. *genitive*	des ..-en eines ..-en ..-en	der ..-en einer ..-en ..-er	des ..-en eines ..-en ..-en	der ..-en — ..-er	der ..-en — ..-er	der ..-en — ..-er
3. *dative*	dem ..-en einem ..-en ..-em	der ..-en einer ..-en ..-er	dem ..-en einem ..-en ..-em	den ..-en — ..-en	den ..-en — ..-en	den ..-en — ..-en
4. *accusative*	den ..-en einen ..-en ..-en	die ..-e eine ..-e ..-e	das ..-e ein ..-es ..-es	die ..-en — ..-e	die ..-en — ..-e	die ..-en — ..-e

5. (*a*) The e of the inflections -e, -em, -en, -er, and -es is dropped in adjectives ending in an unstressed -e, like böse, bad; blöde, shy, timid; müde, tired, weary; träge, lazy; weise, wise. These add only -m, -n, -r, and -s—thus: *s.* 1. der weise Vater, *s.* 2. des weise-n Vaters, *s.* 3. weise-m Vater, *s.* 3. weise-r Mutter, *s.* 1. weise-s Kind.

(*b*) Adjectives ending in -el and -er (edel, noble; heiter, merry) cast off the e of this termination, for reasons of euphony, when they take the flective -e, -er, or -es (der ed[e]l-e Vater, ed[e]l-es Kind, ed[e]l-er Vater, die heit[e]r-e Mutter, heit[e]r-es Kind).

(*c*) When inflected with -em or -en either both e's are retained (heiter-em, heiter-en, edel-em, edel-en), or *one of them* is dropped (ed[e]l-em and edel-[e]m, ed[e]l-en and edel-[e]n, heit[e]r-em and heiter-[e]m, heit[e]r-en and heiter-[e]n, etc.).

(*d*) Adjectives ending in -en (golden, golden), drop the e of this termination when the inflections mentioned in (*a*) are added (der gold[e]n-e, gold[e]n-em, gold[e]n-en, gold[e]n-er, and gold[e]n-es).

(*e*) Adjectives ending in -nen retain the e in this termination when inflections are added (beson'nen, considerate; der besonnen-e, besonnen-em)

(*f*) The adjective hoch, high, casts off in its declension the c of the guttural termination -ch: der hoh-e, hoh-em, hoh-en, hoh-er, hoh-es.

Exercise. Add the missing declensive inflections to the attributive adjectives:

Ein gut... Lehrer (*m*) lobt nicht einen faul...
A good teacher praises not [does not praise] a lazy
Schüler (*m*); der gut... Lehrer lobt den fleißig...
scholar: the good teacher praises the diligent
Schüler. Gut... Lehrer loben die gut... Schüler.
pupil Good teachers praise the good pupils.
Er war glücklich.. Vater einer schön... Töchter
He was the happy father of beautiful daughter.
Xantippe war die böse Gattin eines weis... Mannes.
Xantippe was the malicious wife of a wise man.
Wir saßen in einem dunkel.. (or dunk).. Zimmer;
We sat in a dark room;
er benützte den eben. (or eb...) Weg (*m*); wir wanderten
he used the level way [path]; we walked
auf dem eben.., (or eb...) Wege; der eben.. (or eb...)
on the level path; the level
[ein eben...(or eb...)] Weg ist gut. Wir tranken den
(a level) path is good. We drank the
bitter.. (or bitter...) Wein (*m*); bitter...(or bitt...) Wein
bitter wine; bitter wine
hat einen schlecht... Geschmack (*m*); der bitter... (or bitt...)
has a bad taste; the bitter
Wein war teuer; ich liebe sauer.. (or sau..) Milch (*f.*);
wine was dear; I like sour milk.

Continued

Some Essentials in Making the Shape. Handling the Wire. Bonnet Shapes. Taking Measurements. Covering the Shape.

WIRE SHAPE MAKING

Wire shapes are more used than anything else for foundations of hats, toques, and bonnets. They are light and can be made in the most elaborate of shapes, besides being the only suitable foundation for transparent materials. The wire must be nipped without rubbing the thin silk filaments of wire, or the shape will be spoilt [56, 57 and 58]. It should be placed between the nippers and cut sharply and firmly. To smooth or straighten wire it should be rubbed round the knee or the rounded leg of a table.

Edge wire is much the firmest to use for headline and edge. It is not so easily procured retail as the support wire, which, if necessary, may be used for the whole shape. Support wire can be had in any colour and shade for transparent hats and toques, as it is essential that the foundation shape should match the covering and trimmings.

Some points to be remembered in wire shape-making are these: (1) The wire must be lightly handled, firmly fixed, and not twisted; (2) each part of the shape should be well defined by the position of the wires; (3) round wires are placed underneath the support wires, and the two firmly fixed where they cross each other with mounting wire or cotton [59]; (4) the outer edge of either hat, toque, or bonnet shape must be a continuous wire—if joined or broken, the shape is less firm; (5) leave no great spaces between the wires; (6) avoid breaking the thin silk filament of the wire and leave no sharp edges; (7) unnecessary wires only increase the weight of the shape.

Making Hat Shapes. Cut off a piece of wire the length of headline, plus 2 in. for turnings. Join in a circle, overlapping the wire for 2 in., and bind with mounting wire or strong (No. 10) cotton [60A]. Cut off a piece of wire the length of the circumference of brim, plus 2 in. for turnings. Join in a ring and fix as before [60B]. These are the two principal round wires, and are made of the thicker wire, called "edge wire." Where the wires are joined is the *centre-back* of shape. Divide the headline wire in half and quarters for hat and toque shapes [60A].

Cut off a piece of support wire the size of the circumference tip plus 2 in.; join it in a round, and fix as before [59K]. Next cut off the support wires. Take the ring of wire in the left hand, holding the nippers in the right. Measure from the ring and bend at the length of front brim, plus 2 in., with the nippers; bend again at height of sideband, and again at length of tip front to back. Bend downwards the length of back of sideband, and again at the length of back brim, plus 2 in. [62 and 59, A-B]. The 2 in. left at each end is to allow for turning over the headline wire [58] and for nipping over the edge wire [58B].

The side to side wire [59, C-D] and the diagonal wires, right side front to left side back, are done in the same way. Then take the left side front to right side back [59, E-F and G-H].

When the measurements are very varied it is better to nip the support wires to the headline as they are cut off to prevent their becoming mixed. Hold the headline wire with the left hand, place the first bend of the centre support *under* the centre part of the headline. Then, holding the shape near the headline, bend over the support wire and press in place with the nippers. It is quite firm enough if turned round once. Do not rough the silk filament of the wire.

Repeat nipping in the same way for the centre-back, side, and diagonal support wires. Tie all the wires in centre of tip with mounting wire or strong cotton [61]. Place the wire round the circumference of tip with the join at the back *under* the support wire, and tie wherever they cross [59K].

Measure again the exact measurement of brim, front, back, sides, and diagonals, bending up the wire sharply at the measurement. Nip on to the edge wire (in a shape which has both sides alike, the halves and quarters may be marked), nipping over the support wires once right round. Press firmly, and cut off any piece left quite close [58B]. One, two, or more round wires, according to the size of shape, are tied to the support wires wherever they cross [59J].

Dome-shaped crowns are made in the same way, except that there is only one measurement from headline front to back [63].

In the toque shapes, coronets of bonnets, and brims that turn up very much all round, the edge wire is usually smaller on one side to allow the support wires to curve up [64 and 65]. *Coronets* are shaped brims standing out either round the front, side, or back of bonnets [66 and 70]. When a crown is much larger than the headline, the brim is made separately from it; and for extra strength it has two headlines with about 1 in. between them for sideband [68]. The crown should be made separately, and a much larger headline and circumference of tip will be required. Support wire must be used [67].

Some toque shapes with no crowns have wires stretched across from front to back, side to side, and diagonally [69 A & B]. In this case the double headline is also required.

Making a Bonnet. Measurements for bonnet shapes are taken in this order:

Outside edge all round, noting size of front and back, ear to ear.

Centre-front to centre-back, noting depth of coronet in front, and, if a crown, depth of side-band.

Side to side, noting depth of coronet.
Diagonals, noting depth of coronet in front.
Length of crown.
Width and depth of crown.
Round wires.
Coronet wires.
Width between wires round edge.

For the making, cut off a length of edge wire the first measurement, plus 2 in. for turnings. Join it, keeping the join as the centre-back. Mark the centre-front with cotton, and measure half the front measurement on each side. Then bend the remaining measurement, which should be the same as from ear to ear. If possible, the bonnet should be fitted to see that the shape at back meets the hair, and that the front effect is becoming.

Cut off the middle support as previously explained for hats. In the case of a bonnet with coronet, bend the piece measuring the coronet, plus 2 in. for turnings. Proceed with the side and diagonal wires in the same way, nipping them at the back to the edge wire. Tie the supports in the centre. The coronet wire is nipped on last; it is also made of edge wire, bent into curves or points as required. Then tie on the round wire, nipping it at the back to edge wire.

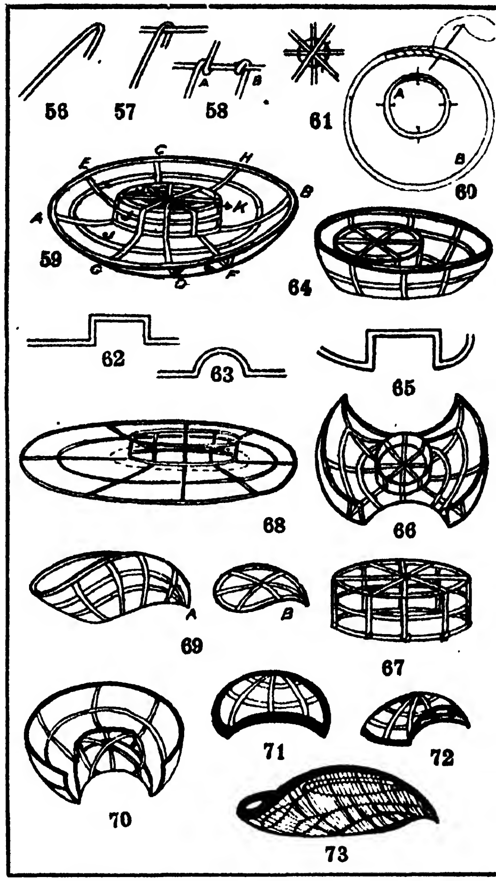
All wire shapes must be covered with tulle, net or chiffon, to take away the hardness of the wire, and to have a foundation on which to sew the trimmings. If the foundation is meant for fur or velvet, leno is better, in which case each part is cut to shape [66]. The edge should be bound with mull or sarcenet.

To cover shapes with net or chiffon, take a piece of chiffon, run it along the edge on the outside, "casing" it on slightly. Cut it up at each support wire, pull the chiffon through at the headline, so that it comes outside, and gather it at centre of tip. Fasten it securely and cut off all turnings [73].

Some bonnet shapes can be covered with the net in one piece. In this case, place the net in the centre of crown, and smooth over the shape with as small pleats as possible. Bind the edge with a crossway piece of velvet, silk, or mull [72].

All bonnets have a velvet fold round the headline, either a crossway piece of velvet, folded double, sewn in before the head lining, or a rouleau, which is sewn in after the bonnet has been lined. This velvet bind is necessary to help the bonnet to set comfortably, to prevent it from slipping, besides keeping the wires from pressing on the head [71].

The shape of individual heads, the manner of dressing the hair, and the shapes of bonnets vary so much that it is almost impossible to judge whether a bonnet will be a good fit or no without trying it on the wearer. If it is found that the bonnet does not reach far enough to cover the sides of the head, note where the headline is situated. It is equally possible that the depth or width of the crown itself may require enlarging.



56-73. HOW WIRE SHAPES ARE MADE.

The headline should sit quite firmly on the head, and have no tendency to slip. In making up, care should be taken that no very thick part of the trimming or lining should fill up the head space, and thus make the bonnet too small.

When the trimming requires to be folded in the line of head, as in a close-fitting shape, allowance for this should be made when making the shape.

Wire shapes to be covered and trimmed with net, or such materials as chiffon, lace, or foliage, are covered with double tulle or net. Floral toques have the shape made of green tubing, slipped on green support wire. Tinsel wire is occasionally used as a foundation for lace or chenille. Chenille, fine braids, and cords, very narrow ribbon, narrow strips of tulle or chiffon, are all used over wire shapes, laced closely over and under the support wire. When these are used in a lattice pattern as trimming there is no need first to cover the shape with tulle or net.

Another way of making a wire shape is over a buckram or straw shape, but as it is liable to be larger than the pattern shape, it is only used in a few cases.

ANTOINETTE MEERBOOM

Protecting Metals. Corrosion. Coating for Ship Bottoms. Painting, Enamelling, Bronzing, Barffing, and Nickel Plating.

COATING AND COLOURING METALS

METALS are coated for two reasons—to prevent gradual destruction by corrosion and for purposes of ornament. Usually both reasons operate, and, consistent with the proper protection from corrosive influences, appearance is usually given the deciding voice. Some processes of protecting metals, including galvanising [page 1590] and tinning [page 1586], have already been described in detail, and we shall therefore ignore them in the present consideration. We shall notice briefly the fundamental facts regarding the other processes; and we shall consider first the protection of iron and steel by painting when protection and not appearance is the object sought.

Corrosion. Iron has an affinity for oxygen, and the result is oxide of iron, which we know as rust. Moisture accelerates the formation of rust, and precautions must be taken to avoid this. In protecting beams which are embedded in masonry lime is used to advantage, and we consider this and some other methods of treating structural steel work further on. Asphalt is the most satisfactory coating for such situations. The asphalt used should be naturally soft or may be made soft by reducing a hard asphalt with a heavy mineral oil.

For cast-iron water pipes the common protection is a coating of Dr. Angus Smith's solution [see TUBE MAKING]; but the process does not give satisfactory results with steel pipes, chiefly because steel pipes are thinner and do not retain long enough the heat necessary to cause Angus Smith's solution to form a hard, impenetrable film upon the surface. Steel pipes are best coated with asphaltum reduced to an elastic varnish by the use of oil, and baked on hard in an oven. On a large scale the work is performed most economically by dipping, the dipping tank being of a form to suit the work.

Painting Iron and Steel. Iron oxide and metallic brown paints should never be used with iron and steel. Such paints are merely iron in a more or less advanced stage of oxidation; in other words, rust. Rust promotes rust. Iron oxide, even in the form of paint, conveys oxygen from moist atmosphere to the metal, and becomes a vehicle for the spread of rust. Zinc oxide paints also are found to peel off, and salvation is found in oxide of lead paints. Red lead forms with linseed oil a hard elastic coating that adheres to the metal surface with great tenacity. Its only chemical effect is to promote the formation of black or magnetic oxide, that prevents corrosion and does not act as a communicating medium for atmospheric oxygen. Red lead in oil "sets" much as plaster of Paris sets when mixed with water; and just as plaster of Paris cannot be worked to advantage after it has partly set, so a red lead paint should not be applied when the process of setting has progressed some way. The usual practice in large shipyards—these may be selected because the work in them demands the best-known practice—is that the red lead is mixed with just enough linseed oil to form a stiff, tough paste, which will keep for several days without hardening. This paste, when required for use, is thinned down with a proper proportion of pure linseed oil and applied at once, care being taken to leave no paint in the pots overnight. By this method the lead and oil "set" on the surface of the metal, and the adhesion is thereby more tenacious than it would be otherwise. The best mixture is 5 lb. of pure linseed oil and 18 lb. of red lead, which make one gallon of paint, and can be made to cover 500 square feet as a first coat, or 600 square feet as a second coat.

The advantages of red lead as a paint for iron and steel are that it dries easily with raw linseed oil without the need for the addition of any "drier," that after it has dried it forms an elastic coat capable of expansion and contraction with the metal, that it does not impart or convey oxygen to the surface upon which it rests, and that it hardens without shrivelling, making a tough and insoluble covering.

All varieties of driers impair the value of any paint applied to iron and steel. The nature of all driers is acid, and any acid will ultimately induce corrosion or oxidation of any iron surface to which it is applied, thereby lessening the stability and protective properties of the applied coating.

Corrosion by Sea Water. Industrially, no process of coating metals is more important than when the objects coated have to withstand the action of sea-water. Utility is the first consideration, and artistic effect, while not negligible, is of much less importance. A few years ago extended tests were made upon steel and aluminium plates in Brooklyn Navy Yard, under the care of scientific authorities, in order to determine the most satisfactory coating to resist sea-water corrosion. Seventy-two plates were immersed in the sea and withdrawn. Sixty of them were left for thirteen months, and twelve of them were subjected to nineteen months' immersion. A careful examination of them after withdrawal was instructive, and led to certain definite conclusions, which may be summarised as follows: Whatever pigment is used for sea work, a more durable coating results if varnish is the vehicle than if oil be used. Further, a varnish coating, or a pigment and varnish coating, withstands sea-water action better when baked on than it does when only air dried. Zinc-white was found to be more durable than any other pigment used in the test, and finally enamel coatings, baked on at high temperatures, were proved more durable than any other coating.

Anti-fouling Paints. In the old days of wooden ships, the hulls used to be sheathed in copper to give anti-fouling properties, but when iron and steel plates superseded wood for shipbuilding purposes, copper had to be discarded. When a plate of iron or steel and another of copper are joined or in mechanical contact in any acidulated solution of water, such as sea-water, the iron becomes electro-positive to the copper, and corrodes rapidly. The value of copper lay in the fact that it protected the wood beneath it from the action of sea-water, and because it constituted a substance with anti-fouling properties; that is to say, that marine organisms did not readily attach themselves to it. The anti-fouling paints or compositions now used are legion. Many of them are secret preparations,

and others are the subject of letters patent. Most of them are sold under proprietary names.

The essentials in a paint for ships' bottoms are that it must be of a nature capable of protecting the surface of the hull from corrosive influences; it must form a smooth surface, so as to offer as little friction to the water as possible; and it must be a rapid dryer, so that the bottom may be cleaned and two coats of paint applied in one day. The compositions used must be adapted to the waters through which the ship has to make her way. For instance, the waters of the Indian Ocean are more fouling than those of the Atlantic, and a composition for use in the former ought to have a higher percentage of a poisonous ingredient. The harder the paint on a ship bottom, the longer it will last. The use of shellac dissolved in spirit gives a coating of the necessary hardness and adhesive powers. The second or external coating should contain a poisonous ingredient that will kill the marine organisms seeking to adhere to the hull surface. Zinc-white, arsenic, copper, and quicksilver have all their use in different compositions. The more scaly the composition the more frequently must it be renewed. In spite of this scaling, such compositions are usually preferred, because as they scale they carry away with them any attached organisms.

Before applying a ship paint, the surface to be treated must be cleaned. All rust must be removed. Better results are attained by a poor paint on a well-prepared surface, than by a good paint on a badly prepared surface. Among the patented anti-fouling compositions we may mention the following:

1. Bitumen, lime, fine sand or Portland cement, and flaky mica—melted together and applied hot.
2. Mix 32 parts of quicksilver with 1 part sulphurised oil of turpentine by grinding in a mortar; add 60 parts of lard and mutton tallow, working the whole into a homogeneous mass. Finally, add 20 parts of litharge which has been ground up in oil. Before using, reduce to proper consistency by stirring in gradually linseed oil, varnish, and 3 per cent. of peroxide of manganese. Any pigment may be introduced to colour any desired shade. This composition is said to be an effective deterrent to the lodgment of barnacles.
3. Tallow, 40 parts; resin, 10 parts; nitreous sand, 10 parts; arsenic, 1 part. Melt together, and mix well.

Celluloid promises to be a valuable coating material for ship hulls [see under DYEING], when the prejudice against it has been dispelled.

Protecting Structural Steel. Apart from shipbuilding work, there are many purposes for which iron and steel must have a thoroughly protective coat of paint. An important field is for structural steel buildings, which are common in other countries, and which are bound to become common in this country whenever the restrictive building laws which prevail with us have been modified so as to make the form of construction economically possible. In structural steel work, the steel joists are almost invariably embedded in cement, or covered with wood, stone, or plaster, so that it is impossible to give them periodical coats of paint as may be done with, say, a bridge or a ship's hull. Hence the need at the time of building to make the pigment covering as durable, as impenetrable, and as free from any agent of corrosion as can possibly be done. The extent to which steel-frame buildings can maintain their strength under different methods of protection has for years been a matter of conjecture and theory. The method of construction is not old enough to furnish precise data regarding corrosion under different condition. Hence peculiar value attaches to the examination of buildings which suffered by the San Francisco earthquake and fire in the year 1906.

Lessons from San Francisco. San Francisco was a city with many steel-frame buildings, and the new San Francisco will follow this method of construction almost exclusively. From the point of view of investigation, the building which attracted most attention when the ruins came to be examined was a nine-storey insurance office, which was erected in 1893, and had therefore done thirteen years of duty. The rust or freedom from rust of the members of the steel framework after thirteen years of use was the point upon which precise information was sought by architects and others. There was very little rust indeed when the steelwork was exposed. Where the steel was covered with lime only, there was found to be a little more rust than when Portland cement and lime had been used together. Where there was rust under the paint, it is thought that care was not exercised in having the surface clean at the time of painting. But, generally speaking, the freedom from rust was so general, and the condition of the members so satisfactory, that all the columns, beams, tie rods, and bolts were sold for use in new buildings in the vicinity.

From the whole experience certain conclusions are drawn regarding steel-frame buildings, and some of these considerations are briefly as follows:

A steel frame, properly painted and buried in masonry, will not rust enough in thirteen years to affect its strength appreciably. The better the steel is coated with mortar, the less it will rust. Portland cement is better than lime mortar for imbedding steel to prevent it from rusting. Unpainted iron rods buried in mortar composed of lime and a large proportion of Portland cement rust very little—certainly not enough to impair their strength. If steel is not thoroughly cleaned before it is painted, the paint will not greatly retard the progress of rust. It is much easier to cover steel thoroughly with concrete than with brick masonry. If brick masonry is to be used, the bricklayer should plaster the steel thoroughly before the brickwork is put up. The quality of paint used, though important, is not so important as surrounding every part of the steel with Portland cement. Cinder concrete does not injure to the slightest degree a steel floor-beam that has been painted.

Paint for Tin and Zinc. In this country tin is not used as a roofing material. But in other countries—conspicuously in Canada—tinplate is an exceedingly common roofing material. A common paint for tin roofs, when they are treated with paint, is made by mixing Venetian red, Spanish brown, or yellow ochre—or these in combination according to the colour desired—with pure raw linseed oil. Such a paint attains a great elasticity, which enables it to expand and contract with the metal without cracking. As tin roofs are generally used only in countries subject to wide extremes of temperature, this property is valuable.

It is extremely difficult to persuade oil colours to adhere to zinc owing to the coating of zinc oxide. But zinc seldom needs painting for protection, as it does not corrode under atmospheric exposure. By means of a special treatment zinc is said to be made capable of taking on an oil paint satisfactorily.

This treatment consists in the application of a mordant made by dissolving 1 part each of chloride of copper, nitrate of copper, and sal ammoniac in 64 parts of water, and thereafter adding 1 part of hydrochloric acid. Under this treatment the zinc first becomes a deep black, but during the drying process this changes to a grey, to which oil colours will adhere satisfactorily.

Cleaning Metals. No matter what process of covering metals is to be adopted, it is essential that the article to be coated should be cleaned if good is to result. There is no exception to the rule. Rust, dirt or grease prevent intimate adhesion, no matter whether the coating be paint, enamel, or another metal to be deposited by simple immersion or by electric deposition. The methods employed for cleaning iron and other metals before galvanising and tinning have been considered on pages 1586 and 1591, and, generally speaking, those methods apply to all metals upon which a fine finish is desired.

The usual method of cleaning for good work is by *pickling* or immersion in an acid bath, and the usual pickle is sulphuric acid and water (1 in 20 to 1 in 30). Where sand has to be removed, as with cast iron sometimes, hydrofluoric acid is better as it dissolves the sand (silica) and is not active upon the metal. After pickling, the work must be washed well with water so as to remove any trace of acid. Where the article is greasy, a solution of caustic soda or of caustic potash in water is the best means of removing the grease. It is best applied hot. When rust has to be removed from iron or steel a good mixture to use is made by mixing 1 part of hydrochloric acid and 6 parts of sulphuric acid in 1 gallon of water; then when the rust has been removed another bath made by dissolving 4 oz. of zinc sulphate in 1 gallon of water and by adding 16 oz. of sulphuric acid completes the cleaning process. Corroded brass or copper is best cleaned by dipping it into a mixture containing 3 parts of nitric acid, 6 parts of sulphuric acid, and 8 parts of water. Corroded zinc may be cleaned by dipping into an acid bath with 1 part of sulphuric acid, 2 parts of hydrochloric acid, and 160 parts of water. For dirty lead, tin, and pewter a hot caustic soda solution is best.

Polishing Metals. For work of a high order such as enamelling and plating the mere removal of rust and grease is not enough. It must be polished if the resulting surface is to be excellent. There are many methods of polishing. Sand blasting we have described elsewhere [see page 1727]. It is used chiefly for brass and other soft alloys. Other processes are stone and emery grinding, scratchbrushing, and buffing. The methods adopted depend upon the condition and nature of the work and upon the finish desired. Preliminary processes where the surface is coarse consist of grinding upon an emery or corundum wheel [see page 1727]. For finer work polishing lathes are used. These have circular wire brushes, hair brushes, leather bobs, felt bobs, or cotton bobs revolving at high speed. Wire brushes are usually lubricated with some liquid such as stale beer, the object being to keep the brush from becoming too hot and to prevent it from cutting into the metal. With the other forms of brushes or bobs, polishing powders or polishing compositions are used. The usual best practice is to have the polishing material in the form of a cake and to apply it to the bob simply by holding it in contact as the latter revolves. The materials are composed of rottenstone, pumicestone, emery in various degrees of fineness, crocus, tripoli powder, and rouge. Tripoli is used coarse, for instance, for brasswork and small iron and steel, while if the work is to be plated fine tripoli and crocus are used. Rouge is used for finer work still—for cutlery and jewellery. Any of these compositions and materials can be used with hand polishing brushes and tools, but this practice is laborious and costly, hence seldom used in manufacturing industries.

Blueing Iron and Steel by Heat. Small articles of polished iron or steel may be blued easily by the use of heat. The most convenient method of applying this heat is by the agency of a Bunsen burner, which yields a hot flame but does not smoke. Another common method, especially for flat work, is to heat a flat piece of iron and steel—sufficiently thick to retain its heat for a long time—and to place the small objects upon its hot surface in direct contact or upon a piece of sheet iron interposed between the two. The Bunsen burner, when properly constructed, should burn with a light blue flame, having within it a blue-green flame, the apex of which is the point of most intense heat. The article being heated should be held immediately above this point of greatest heat. Watch the change in colour as the iron or steel article rises in temperature under the heat. Withdraw it from the flame before it quite comes to the desired shade of blue, hold it in the air until the desired tone appears, and at this point throw the article into oil—preferably a heavy oil, such as fish oil or lard oil—where it may be allowed to cool. When the article being treated is of uniform shape, the work is easy; but where the shape is irregular—say, thick at one part and thin at another part—greater care and practice is necessary to secure uniform results. In such a case the heat must be confined to the thicker part for a longer time than is necessary for the small parts. Another method of attaining the same result is to heat sand very hot in a pan, then to immerse the articles in the sand, and to roll them around until the desired shade appears, when the colour is fixed by the oil-bath, as already stated. By all of these methods the iron or steel passes through the following colours—pale straw, dark straw, brown, purple, blue and green, as its heat increases, and it may be arrested at any one of them.

Of the many other recipes recommended for blueing iron and steel, the following may be put on record: A solution of 1 oz. lead acetate and 1 oz. sodium thiosulphate in 50 fluid ounces of water, being used hot, imparts tones from a light brown bronze to black, according to the duration of the soaking, the intermediate tints being purple, blue, light blue, and steel grey.

Lacquering. Metals may be lacquered both to preserve them from atmospheric action and to improve the appearance. The usual transparent lacquer is made by dissolving shellac in methylated spirit and colouring matter such as dragon's blood for red, and gamboge or turmeric for yellow, while a wide range of colours is secured by introducing the aniline dyes. In applying the lacquer the article being treated should be kept warm at a uniform temperature. The work should be done where there is no dust floating about, and the operation should be performed rapidly and smoothly. The lacquers should be kept in stoppered bottles, which are best when of opaque glass. They should be applied with a thin, wide and flat brush. [See Graham's table of lacquers on the following page.]

Enamelling. Enamelling is perhaps the most common of the processes of coating small articles of iron and steel. We refer not to the vitreous enamelling such as is found on the enamelled milk saucepan and the enamelled mug, but to the ordinary enamel paints which are applied either by a brush or by dipping and afterwards hardened in an enamelling stove. Articles enamelled in this way are found in every household—the iron bedstead, the coal-scuttle, the room fender, and many other articles of domestic use. This sort of enamel is merely a fine paint, which is dried and hardened by heat.

COMPOSITION OF LACQUERS.

Number.	Shellac.	Mastic.	Canada balsam.	Spirits of wine.	Pyro-acetic ether.	Spirits of turpentine.	Turpentine varnish.	Simple pale lacquer.	Dragon's blood.	Annatto.	Sanders.	Turmeric.	Gamboge.	Saffron.	Cape Aloes.	Sandarac.	
	oz.	dr.	dr.	pt.	oz.	dr.	oz.	pt.	dr.	dr.	gr.	dr.	dr.	dr.	dr.	dr.	
1	4	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	Strong simple.
2	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	Simple pale.
3	1	—	—	1	—	—	—	—	—	—	—	—	1	—	8	—	Fine pale.
4	1	—	—	1	—	—	—	—	—	—	—	1	1	2	—	—	"
5	1	—	—	2	—	—	—	—	1	1	—	—	16	4	—	8	"
6	2	—	—	2	—	—	—	—	1	8	—	32	—	—	—	8	Plate gold.
7	2	—	—	1	—	—	—	—	—	—	—	—	2	—	4	—	Pale yellow.
8	5	—	—	3	80	—	—	—	—	—	—	—	—	—	—	—	"
9	—	—	—	—	—	—	—	1	—	1	—	4	—	—	—	—	Full yellow.
10	3	—	—	1	—	—	—	—	—	2	—	16	—	2	—	—	Gold.
11	3	—	—	4	—	—	6	—	—	—	—	64	6	—	—	14	"
12	1	—	—	1	—	—	—	—	—	—	—	20	—	—	2	5	"
13	3	—	—	1	—	—	—	—	4	—	—	16	—	—	—	—	Deep gold.
14	3	—	—	1	—	—	—	—	4	—	—	1	—	—	—	—	"
15	3	—	—	1	—	30	—	—	40	—	12	10	—	—	—	—	"
16	—	—	—	—	—	—	—	1	8	32	—	—	—	—	—	—	Red.
17	1	—	—	—	—	—	1	—	8	24	—	—	—	—	—	27	"
18	15	30	30	6	—	—	—	—	20	—	—	40	—	10	—	—	Tin lacquer.
19	—	—	—	—	—	—	—	1	—	—	—	4	1	—	—	—	Green, for bronze.

The Enamelling Stove. An enamelling stove is necessary for the work. It is best heated by Bunsen burners. Enamelling stoves may be purchased from makers who specialise in them, but any ironplate worker can make one without difficulty, and if proper precautions be taken, the home-made article is often better than the factory stove. A ventilator at the top permits a current of hot air to circulate through the stove. It is an economical provision to have the walls lined with a non-conducting material, such as fireclay, so as to prevent unnecessary heat radiation, thereby reducing the amount of gas consumed to maintain the proper heat. The sides should be fitted with angle iron bars upon which bars or shelves may rest to support the work. The door should be made the whole width of the front, thus permitting easy ingress and egress of the articles before and after enamelling. It should also have fixed to its inner side a thermometer registering up to not less than 400° F., and capable of being inspected from the outside. The usual device is to have an oblong panel cut from the door in front of the thermometer and fitted with a sliding or swinging cover which can be removed when it is desired to read the temperature. The gas supply should be in excess of requirements so that the proper heat can always be secured. The heat is regulated by raising or lowering the gas jets or by lighting or extinguishing one of the Bunsen tubes.

For many purposes—a cycle frame, for instance, or a fine cast-iron stove—a fine polish is essential. The finer the polish the finer is the resulting coat of enamel. The polish is obtained first by grinding on a grindstone, or an emery wheel if the work be rough. For work that is not rough originally, polishing with a fine emery bob and then with a leather and cloth bob is sufficient. Some work is "sweated" before having the coating of enamel applied—that is, rubbed with a cloth wrung out of spirits of tar and placed in the stove at full heat of, say, 300° F. to 400° F. for a quarter of an hour.

The Coats of Enamel. Some articles may have only one coat of enamel, in which case the finishing enamel is that applied, but in most cases a first coating precedes the finishing coat. The article is either painted with the enamel by means of a brush, or dipped into a bath or trough containing enamel. If the brush be used, it must be of good quality so as to lessen the likelihood of hairs adhering to the surface. A hair cannot be removed after the enamel has been hardened without leaving a blemish. The size and shape of the trough, if dipping be practised, must be decided by the shape of the articles, but a trough is used only where enamelling is on a large scale.

The enamels are purchased from firms making a speciality of their preparation. The enameller need not think of making them for himself. The work having received its first coating, is placed in the stove, and is given the necessary heat for a period depending on the colour and quality of the enamel. For black enamel the heat is usually from 300° F. to 350° F., and for coloured enamels about 125° to 150°. Care should be taken not to give the full heat at once. The time required at this heat is usually between one and two hours, and must be decided by experience. Keeping the work in the full heat for too long a time makes the enamel easily chipped besides consuming unnecessary gas. When the gas is turned off the enamel is hot, but wet. When it has dried the article is polished with a paste made of pumicestone in an impalpable powder or crocus and water. All roughness should be carefully removed in this polishing.

The finishing coat—not of the enamel formerly used, but of "finishing enamel"—is then given. It must be applied in a thin coat or the finished appearance will be blotchy and shrivelled. The work is again put into the stove and the full heat maintained until it is slightly "tacky" or "gummy" when touched. Then turn out the gas and allow the article to cool. The article is enamelled. If a still higher degree of finish be desired, this second coat may be rubbed smooth with the paste as before, and a third coat—another of the second or finishing coat—applied, but this is seldom done.

The enamels should always be kept corked when not in use, so as to prevent dust or other extraneous matter getting into them. As much work as possible should be put into the stove at each heating, thereby diminishing the cost of gas upon each article.

Vitreous Enamelling. The process of applying a coating of vitreous enamel to articles of metal has during the last few decades spread from the field of ornament into that of utility, and an enormous industry, which flourishes especially in Germany and Austria, has grown into being. Street signs, and culinary and domestic utensils are the articles to which vitreous enamel is most frequently applied. In Continental Europe cast-iron work, such as coal stoves, is treated to this variety of enamelling, but in this country its use in this direction is limited.

Enamel is merely a coating of a glass applied with an ingredient such as tin oxide or bone ash to render the glass opaque. Into coloured enamels other ingredients are introduced, in accordance with the colour desired. White is by far the most common variety of enamel used for coating articles of metal, and blue comes second in importance. In America, however, mottled or "granite" ware is more common than white. A knowledge of the properties and composition of glass is essential to the manufacturer of enamels, and reference may be made to the article on glass manufacture.

A *flux* is necessary to cause the enamel to adhere to the surface of the metal. Borax is the flux at once the most easy to work and that most generally employed. Other fluxes are fluorspar, broken glass or *cullet*, gypsum, clay, and broken porcelain. These fluxes are used alone or in various combinations according to the class of work under treatment.

To introduce colour into enamel many metallic oxides are used. The chief pigments in general use are as follows:

To give blue—Cobalt oxide and cobalt silicate.
„ black—Ferrous oxide.
„ brown—Ferric oxide.
„ green—Ferrous oxide (in small quantities), cupric oxide or chromic oxide.
„ red—Ferric aluminate, tin-gold chloride, sodium-gold chloride or purple of Cassius.
„ yellow—Oxides of silver, iron, uranium, and antimony or antimonate of potassium or lead.
„ violet—Oxide of manganese.

Lead in Enamels. Lead ought to be absent from enamel applied to any vessel intended to contain food. On account of the affinity of lead for silica a lead enamel is an easy one to manipulate, and makers of cheap enamel ware use it extensively. But it cannot be too strongly urged that its use is dangerous. The presence of lead in the enamel of an article may be detected by several simple methods. If weak vinegar be boiled in an enamelled vessel, and if as a result the surface of the enamel becomes dull and rough, lead is present. This test will also throw lead into solution in the vinegar. Another test is to beat up an egg in an enamelled vessel, and allow it to stand for twenty-four hours. The sulphuretted hydrogen in the egg will darken the lead oxide and cause the enamel to show a stain. For most pieces of chemical apparatus also an enamel containing oxide of lead is bad, as the lead may enter into chemical combination and vitiate or modify the results attained. There are many recipes for leadless enamels. Mr. Paul Randau vouches for one as being in use in some large Austrian enamel works, and we give the formula:

Silica	30 to 50 parts
Flint	10 „ 20 „
Kaolin	10 „ 20 „
Pipeclay	8 „ 16 „
Chalk	6 „ 10 „
Ground porcelain	5 „ 15 „
Boric acid	20 „ 40 „
Saltpetre	6 „ 10 „
Gypsum	2 „ 5 „

Enamel adheres better to charcoal iron than to coke iron, and in cast iron to "white iron" rather than to "grey iron." White iron, however, is rather hard and brittle for most purposes to which enamelled iron is put, hence a mixture of white and grey pigs are generally used in cast iron that has to be enamelled.

Preparation for Enamelling. To prepare iron and steel for the coating of enamel, they must be pickled in diluted acid, a process which has been described in some detail in our descriptions of galvanising and tinning [see pages 1586 and 1591]. If greasy, treatment with caustic soda removes the grease. The articles are then scoured with clean, sharp sand until quite bright. Many mechanical devices are adopted to secure economy of work and big output in large works, but we shall not stay to consider these devices here. A common one is a sand blast apparatus. After scouring, the work is dipped into boiling water, drying immediately after withdrawal, when it is ready for the enamel coating.

The under coat is then applied. The enamel is usually kept moist, and is therefore like clinging sand. Before application, it is reduced with water to the consistency of cream. The workman ladles into the vessel, the interior of which is to be enamelled, as much of this enamel cream as experience teaches him will suffice for the work, and by means of a stiff brush he spreads it over the surface to be coated. Any excess is allowed to drip off, but practice enables the workman to dispense with the necessity of draining. The work coated with this enamel is then taken into the drying-room, preferably heated by steam pipes, and after remaining there about one hour, the article is dry and ready for firing, for which purpose it is taken to the muffle furnace.

The muffle furnace is of the ordinary type, and must be of a capacity to suit the work. But workshop economy demands that it should be made quite full every time it is heated, hence there is danger of expense in having the furnace too large. It is better to increase the number rather than to increase the size of the furnaces; but there must always be one large enough to accommodate the largest piece of work likely to be treated. The fuel for the furnace may be that most convenient to the district. Gas may be chosen with advantage, if it be available, as it allows the temperature to be regulated perfectly.

Firing the Enamel. The object of the muffle forms of furnace is, of course, that the contents may come under the full heat given off, but may yet be secure from the dust and smoke that would surround them if there were no muffle. It is usual to have the greatest heat at the back of the muffle, so that the articles are not subject to the extreme heat immediately after insertion. The work is put into the muffle when the front of the latter is at a dull red heat, and the back portion at a bright red heat. The pieces of work are moved about by the workman into the hotter or cooler portions as they seem to require it. One expert man can attend to a round dozen of muffles, filled with work. From twenty minutes to half an hour ought to suffice for this firing. After that time, the enamel will have fused over and on to the metal. It will still have the powdery effect which it had when it entered the furnace, but the powder can no longer be rubbed off with the finger, and close examination will show that the adhering particles have lost their sharp edges. If the powder does not adhere well in the manner indicated, the enamel composition is too refractory, and must have some borax stirred into it. If, on the other hand, it be very smooth on its surface, it is too fusible, and the enamel mass must have some clay or flint added to it to make it more refractory.

The Final Coat. The covering coat is applied after the article has been withdrawn. If there be any exposed iron which was not intended to be enamelled, and was therefore not coated with enamel composition in the first instance, the firing will have made it black. This black, which is black oxide of iron, must be removed with wire brushes. The finishing layer of enamel is now applied in the same manner as the first was. The thinner it can be made, consistent with efficient covering, the higher will be the finish and the greater the durability of the finished article. The temperature of the muffle furnace for the finishing coat is kept a little lower than it was for the first layer, as the composition is more easily fusible. Also the articles are moved about in the muffle,

and turned more frequently, so as to secure uniformity in the process of fusion. When it is considered that they have had enough of the fire, they are removed, but ought to be allowed to cool gradually, otherwise the enamel may crack in the cooling. There is frequently a separate muffle at a dull red heat, into which the articles are placed and allowed to cool slowly. The enamelling is now complete.

Cheap enamel ware is frequently made with only one coating of enamel, but good work that will stand the test of use, especially if it be for articles for cooking, demand two coats. The first, or ground coating, should be somewhat porous, and the upper or covering layer forms the impenetrable glaze.

Decorating Enamel Ware. The common method of decorating enamel ware is by means of transfers as used for pottery ware. The ink with which these transfers are printed must be made of fusible oxides. To fix a transfer to an enamel surface is not difficult. It is applied, the back of the transfer is damped with a sponge, and the article is fired, so as to fix the ornamentation. Hand decoration is also practised, and is the common method when bands are being put on the outside of vessels, but for elaborate work its cost is prohibitive. Mottled or *granite* enamel ware is made by spraying upon a coating of white or yellow enamel a covering, or rather a partial covering, of coloured enamel. It is then fired in the usual way, and if a good surface be desired, it is treated with a final transparent enamel glaze.

Colouring Metals. The numerous processes for bronzing metals may be divided into three classes, depending for their action upon chemical change, electro-chemical change, and mechanical application. The first and the second might properly be classed as one, but electric deposition is such an important and such a distinct process, that it may well be elevated into a class apart.

All metal articles may be treated to an application of bronze powder, caused to adhere to the surface of the metal by a special varnish. Bronze powders are made in dozens—indeed, hundreds—of shades, and their manufacture is a huge industry in Austria, which supplies the greater part of the world with them. The so-called *bronze* powder is simply metallic brass, copper, aluminium, or other metal or alloy in a very fine state of subdivision. The particular depth of shade is usually obtained by oxidising more or less the metal in the manufacture of bronze, but with this, the man who applies the powder has no direct concern. [See also page 1723.]

The article to be bronzed is usually coated with a special varnish. This varnish, or *size*, had better be purchased from varnish manufacturers, but a good recipe for its manufacture is as follows: Boil linseed oil for two hours, and add to it gradually, when boiling, 5 per cent. of its weight of red litharge, followed by 5 per cent. of white litharge. If the first addition of red lead cause the formation of a red scum, the oil is at too high a temperature, and the further addition of red lead must be delayed until the oil has cooled somewhat. The mixture is kept for about a week, and is then ready for use.

The iron or other article to be bronze-coated is given a coat with the varnish or size, and when this varnish has become almost dry, or, as it is called, *tacky*, the bronze powder is applied, usually with a brush. Then, when the varnish has quite dried, the surplus powder is brushed off and the article is bronzed. It may be coated with varnish again, and will, after this precaution, resist atmospheric action and retain its freshness much longer than it otherwise would. It must not be forgotten, however, that any varnish applied after the bronze powder diminishes the metallic brightness, so that the manipulator must choose between brilliance and durability.

An expeditious, economical, and satisfactory method of applying bronze powder is by mixing it up like ordinary paint, with the varnish as a base, and by painting it on the surface to be decorated. Two coats are desirable, and, of course, these may be thinner than a one-coat application. Turpentine is the medium used to thin the varnish. The hardness and durability of the bronze coating is much increased if the article be dried in a japanning stove. The temperature should not be high—not more than 200° or 250°—and half an hour is about long enough time to allow.

Bronzing Brass by Immersion. There are many simple immersion baths used to bronze metals, and the tone resulting depends upon the duration of the immersion. Brass may be coloured any shade from brown to black by a bath made by dissolving 2½ oz. of nitrate or perchloride of iron in 1 gal. of water. Any shade from brown to red may be secured by immersion in a solution containing ½ lb. nitrate of iron and hyposulphite of soda in 1 gal. of water. Yellow to red demands a bath where ½ oz. tersulphide of arsenic, and 3 oz. of pearlash solution have been dissolved in 1 gal. of water. Potassium sulphide added to water (½ oz. to 1 gal.) gives orange bronze; a mixture of perchloride of iron and water (1 gal. to 2 gal.) gives an olive green, while sulphocyanide of potassium (20 oz.) and water (1 gal.) gives a blue.

Bronzing Copper by Immersion. Bronzing copper baths, used simply by immersing the copper articles in the solutions, are as follows, the chemicals mentioned being dissolved in 1 gal. of water:

Brown to black, 2½ oz. nitrate of iron.

Dark drab, 2½ oz. nitrate of iron and 1 oz. sulphocyanide of potassium.

Bright red, 1 oz. sulphide of antimony and ½ lb. pearlash.

Red to black, ½ oz. sulphur and 1 lb. pearlash.

Steel grey, ½ oz. chloride of arsenic (must be applied at 180° F.).

Japanese Lacquer. Japanese lacquer is valuable as a metal coating, and when once the secret of its manufacture has been given to the Western world, its use will extend. But at present its precise method of preparation is held as a jealous secret. It is known to be made from the secretion of a tree, the *Rhus vernicifera*, called by the Japanese the *urushi-naki*, which grows to a height of about 30 ft. when it attains its full yielding capacity. The lac is collected by making horizontal incisions in the tree. The issuing lac is milky white and thick, but on exposure becomes first dark brown, and finally black. The lac is purified by being strained through cotton-wool, then by rubbing it on a paint slab and mixing it well with water, which is finally evaporated by heat. The further treatment in preparing the famous Japanese lac varnishes is not known outside of Japan. White and pure light colours cannot be obtained in these Japanese lacquer varnishes. The usual colours are brilliant black, impure vermilion, impure dark green, and dark grey. Drying is done in twenty-four hours in a moist atmosphere, and if the articles to be dried are placed in enclosed rooms, the walls and floors must be wetted down periodically, so as to provide the moist atmosphere. Fine lacquer work requires 18 coats; it improves in colour with age. If Japanese lacquer

were used only for bric-à-brac and woodwork, we would not give its description space in this article, but it has a much wider use than that held by general opinion. It is widely used for metal coating —the Japanese use it for acid tanks, for ship's coating, for coach and decorative panels, and for domestic articles, which it enables to resist hot water, soap, and alkaline solutions. It never splits or cracks, and has great durability. Applied to the hulls of ships, Japanese lacquer forms a coat both anti-corrosive and anti-fouling. The coats applied to hulls vary in composition, the first being almost pure lacquer, and the succeeding coats containing proportions of mica or kaolin to increase the covering power. When first used as a ship's paint, anti-fouling paints were applied over the lacquers, and this method was a failure, the urustric acid in the lacquer attacking the metallic base of the anti-fouling paint, the result being that the virtues of both were destroyed. Later, it was found that the lacquer alone is an admirable anti-fouling paint, as well as an anti-corrosive protection.

The Bower-Barff Process. The Bower-Barff process of coating iron and steel is old, the two inventors from whom the process derives its name having registered their patents over twenty-five years ago. But the process did not obtain prominence or commercial success, on account of certain inherent difficulties which gave bad results. It remained for followers of the original inventors to carry the process some way nearer perfection, so that the modification of the original process now followed by those who practice *barffing*, as it is usually termed, may be said to be both a practical and a commercial success.

The root principle of the barffing process lies in this—that when iron or steel is made red-hot, and steam is brought into contact with it, the surface undergoes a chemical change and becomes black oxide, or, as it is more properly called, magnetic oxide of iron. We need not waste space in describing the plant used by Bower and by Barff respectively in achieving their objects. Our time will be better occupied in paying attention to the modern improvements upon the original methods adopted.

No other metals but iron and steel can be subjected to barffing with successful results, hence its use is somewhat restricted. But the process is less expensive than galvanising, and, if carried out as it now can be carried out, the surface given to the metal is even more resistant to corroding influences in exposed situations. The finish is a dark slate or dead black—the natural colour of black oxide, and the depth deepens upon the length of time to which the articles are subjected to the process. The bad results in early attempts were that the magnetic oxide surface given to the iron or steel was very hard and brittle, being liable to scale. This difficulty has now been almost entirely obviated. Certainly, articles barffed today do not give evidence of peeling in the manner and to the extent that formerly prevailed.

The present-day practice usually followed is the Gesner modification of the original. This consists in heating the work in a closed retort, and injecting steam for some time. The steam is shut off, and a small quantity of naphtha is admitted, after which steam is again injected. Finally, the work is allowed to cool naturally, and is then finished.

The Barffing Furnace. The furnace used is much like a coal-gas furnace, consisting of one or more clay retorts, which may be made to open at one or both ends. The fuel used is immaterial, as the work is isolated from the fumes, and local convenience decides the point. Steam is led from a boiler into the retort by a suitable pipe. The steam need not be under pressure, and an ordinary house boiler is quite suitable for its generation. The steam-pipe is led along the bottom of the retort, protruded from the end opposite to that by which it entered, is returned, and its end led into the retort again. The object of thus causing the steam-pipe to travel the whole length of the retort before the steam is allowed to escape is that the steam is superheated before coming into contact with the work. This is an essential feature of Gesner's method. Another essential feature is the use of a hydrocarbon, such as naphtha, with the steam. The theory of the inventor of this process, and his claim to success, rest in the fact that the steam, passing through the red-hot pipe in the bottom of the furnace, is partially reduced, that hydrogen and oxygen are set free, and that these, acting in conjunction with the steam, give a coating of magnetic oxide containing hydrogen. Such a coating is, by experience, found less liable to scale than one devoid of hydrogen. Analytical tests made have shown that the magnetic oxide coating contains about 1 per cent. of hydrogen. The door of the retort is made reasonably tight to prevent the escape of steam, and clay is plastered around it with this object. An exhaust pipe is led from the top of the furnace into a water-seal, which gives a low pressure in the retort. About 1½ in. of water is usually all that is given. The arrangement of the furnace is calculated to give as nearly as possible a uniform heat in the retort.

The articles to be barffed must be free from scale and dirt. The better and smoother the finish before barffing, the better is the resultant coat of black oxide. The castings or other articles under treatment may, if greasy, be treated with caustic soda; but if free from grease this is unnecessary. To remove scale or dirt, they may be pickled or sand-blasted. The latter treatment is the better.

Operating the Process. The retorts in which the work has been placed are heated to from 1000° F. to 1200° F., and the steam admitted for about 30 minutes, and then about a pint of naptha is allowed to enter through a pipe for that purpose. Then steam is allowed to enter alone for about another 30 minutes, and is finally shut off. When the retort has cooled to about 800° F. the articles are removed, and, to prevent marks or imperfections on the surface, they are put into paraffin or other heavy oil while still hot. They are taken out afterwards, the oil is removed by immersing the articles in benzene, and a coating of flat lacquer or wax or both is given. A little polishing follows upon a rotary bristle brush. For coarse work, such as cast-iron furnace pans, for which barffing is largely used, many of the refinements enumerated above are not practised, as this would raise the cost where cheapness is of more importance than elegance; but for light hardware the process usually employed is that we have described.

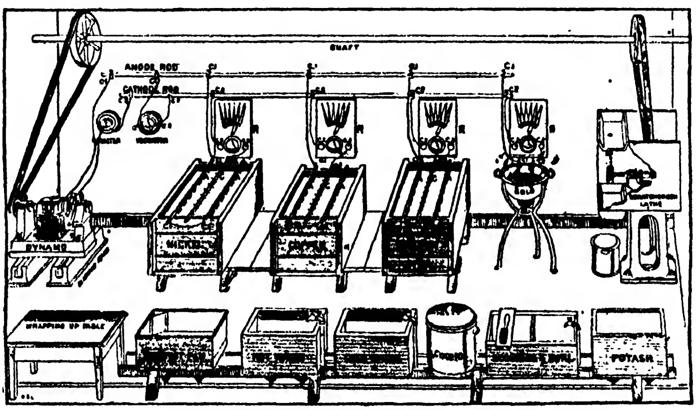
The cost of the process for large work, such as furnace pans, may be as low as from 4s. to 5s. a hundredweight, but for lighter and smaller articles it is much higher, and may be as much as 20s. a hundredweight. The expense in small articles is because every article placed in the retort must be deposited so that every part of its surface may be subject to the action of the steam.

The original process of barffing increased the size of the work, and, as the work could not be machined afterwards without destroying the surface produced, provision had to be made in initial preparation.

The formation of hydrogen during the modified process we have described seems, however, to prevent this enlargement, and machined work—screws, nuts, valves, and other articles—may now be made to finished sizes and barffed without fear that the process will disturb the fitting.

Electroplating. The principles and the practice of electroplating are treated in the course on ELECTRICITY on a later page, and it is assumed that the reader is making himself familiar with the instruction given there. Space may be spared here for some practical information upon the equipments required for various classes of work and for different volumes of output.

The most common form of electroplating is a deposition of a deposit of nickel upon steel or iron, and in many plating shops, particularly in the cycle trade, no other work is undertaken. We may therefore consider such a shop. A plating plant, capable of treating up to 30 sets of cycle fittings per week, would include a dynamo (6 volts, 100 amperes) driven at 1,200 revolutions, and requiring 1½-horse power; a nickel vat, 4 ft. by 2 ft. by 2 ft. deep; a copper vat 30 in. by 18 in. by 18 in. deep; and a polishing lathe. It is never wise to purchase a plant that will overtake only the amount of work available at the moment, as in the event of increase of work the plant will not be able to rise to the work. It is considered well that the capacity of the plant should be 30 to 50 per cent. higher than there is immediate occasion for. The size of the vats and the quantity of solution depends upon the quantity and size of the articles to be plated. Every square foot of surface of work being plated requires 10 amperes of current, and this forms the guide in determining the size of the dynamo necessary. The dynamo should be fixed in a convenient position as close to the vats as possible. The grinding and polishing should never be done in the same shop or room as the plating.



ARRANGEMENT OF PLATING SHOP

The Plating Plant. A complete plating plant, as arranged by Messrs. Canning, of Birmingham, is illustrated herewith. The plating vat must be lined with chemically pure lead with burnt joints. The nickel anodes should be pure cast nickel plates, having an aggregate surface at least equal to the surface of the work, and if rolled nickel plates be used at all they should not be more than one to four cast anode plates. The nickel solution is made by dissolving sulphate of nickel in water. The trade in this country usually employ Canning's special nickel salts—a double sulphate of nickel and ammonium—dissolving one pound by weight in one gallon of clean boiling water in a vessel of wood, earthenware, or enamelled iron. The solution as it becomes impoverished is brought to strength again by the addition of more nickel salts. It must be kept neutral, and if through use it becomes acid, ammonia is added in small quantities to bring it to neutrality. The anodes are suspended in the tank from brass rods as seen in the illustration, and the articles to be plated are also suspended from suitable hooks or baskets. The best practice is to have anodes at each side of the work so that with three rods the centre one carries the work and the other two the anodes, and if five rods are used the centre and the side rods carry anodes. A recent improvement in electroplating plant has been introduced by Messrs. Canning and widely adopted. By mechanical agitation of the electrolyte the current density is increased, and the time taken to form the electro deposit is reduced by as much as one half. The direct result of the introduction of mechanical agitation is to double the capacity of any plant.

Electro-brassing and Electro-coppering. The same process as for nickel plating is used in depositing any other metal, but the anodes used must be of the metal it is desired to deposit. Thus, anodes of gold, platinum, silver, brass, copper, tin, or zinc are used as required. We may take as typical electro-brassing, as after nickel plating it is the most generally practised. The electrolyte used may vary in composition, but the following is good (Canning):

Pure cyanide of potassium	1 lb.
Carbonate of copper ..	8 oz.
Carbonate of soda	3 oz.
Bisulphate of soda.. ..	1 oz.
Water	1 gal.

In making, dissolve the cyanide of potassium in three quarts of hot water, and add the carbonate of copper. In a separate vessel dissolve the carbonate of soda and the bisulphide of soda in one quart of hot water. Mix the two solutions when cold and stir well. The electrolyte may be used either hot or cold; if the latter, the temperature should be 120° to 140° F.

Before immersion the work must have been thoroughly cleaned in hot cleaning solution (hydrochloric and sulphuric acid in 10 parts of water) and swilled, then scoured with powdered pumicestone and again swilled. The full details for depositing other metals cannot be given in this article. There are several good textbooks to guide the novice; the "Handbook on Electroplating," published by Canning & Co., of Birmingham, may be recommended.

Finishing Plate Articles. When a nickel-plated article leaves the electrolyte it has a dull-white appearance. It must be finished. It is first rinsed in hot water and then dried. Then it goes to the finisher, who, with the aid of mops made of felt, calico or swansdown, usually mounted on a polishing lathe, polishes the work, the final touches being given with a soft clean mop. The first mop is usually charged with dry Sheffield lime or with tripoli powder.

Debentures. Terms of Issue and Redemption. Income Tax Assessment. Exemption, Abatement, and Repayment. Super-Tax.

THE DOUBLE-ACCOUNT SYSTEM

When a dividend is declared by a company a dividend account is opened and credited by the amount to be paid, the profit and loss appropriation account being debited. As the dividend is paid the dividend account is debited and cash credited. The dividend is always calculated upon the amount *paid up* on the shares, and the forfeited shares do not participate.

The appropriation of profit account, given below, and the liabilities side of the balance-sheet, shown on the following page, are suitable for the company whose opening capital entries have been already given and explained. There is one item in these liabilities which requires some explanation.

Loans on Debentures. Limited companies frequently avail themselves of the facilities afforded by debentures to borrow money for the purpose of acquiring or carrying on their undertakings. Debentures are of two kinds: (*a*) those which are a mere acknowledgment of money lent; (*b*) those acknowledging a loan and giving a charge or mortgage upon the company's property as security for the repayment of the sum advanced. Both kinds are given under the seal of the company, and carry interest at a fixed rate during the time the loan is outstanding. The latter class are by far the more numerous, and, by reason of the security which they give, are a favourite form of investment with the capitalist who is content with a smaller return for his money than he might look for from shares. They are known as mortgage debentures, and are the kind here dealt with. Debentures may be either redeemable at a fixed date or they may be irredeemable.

The difference between a debenture and a share is of the utmost importance. The holder of the former is a creditor of the company for the amount of his loan, and is not merely an ordinary creditor, but one holding security for payment of his debt. If the company fails to pay interest on the due date, or if it defaults in repayment of the principal at the stipulated time, or is wound up, the debenture-holders usually have a right to take possession of the property and realise it for the purpose of satisfying their claims. After they have been paid, any surplus would belong to the ordinary creditors of the company, and the shareholders would be entitled to anything there might be left only after these claims have been discharged. The debenture-holders, therefore, come first, as secured creditors, the shareholders last, as proprietors of the concern.

Issue at Premium or Discount. Invitations are often given to the public to subscribe for debentures in the same way as for shares—*viz.*, by means of a prospectus. The procedure as to application and allotment is practically the same as in the case of shares, and the entries in the company's books are very similar. The broad result is the debiting of cash with the amount received, and crediting a "Debenture Account," instead of a share capital account. A register of debentures is kept, which is ruled in very much the same way as a register of members and share ledger, the headings being altered to correspond with the different circumstances. Debentures may be issued either at par, at a premium, or at a discount, and may be redeemable either at par or at a premium. If they are issued at a premium, the extra amount received will be debited to cash and credited to a "Premium on Debentures Account." The amount of the premium will represent a gain to the company, for there will be no liability to the debenture-holders in respect of the sum paid in excess of the nominal amount of the debentures. The premium is the bonus the applicant is willing to pay in order to become a holder of the debentures. It cannot be distributed by the company by way of dividend, but is either treated as a reserve fund or used in reduction of any preliminary expenses the company has paid in establishing the business.

Dr.	PROFIT AND LOSS APPROPRIATION ACCOUNT					Cr.
1906. Dec. 31	To Interim Dividend paid on Ordinary Shares for half year @ 8 % per annum	190 0 0	June 30	By net Profit from Profit and Loss account.. ..	1,456 9 8	
1907. June 30	,, Reserve Fund.. ..	500 0 0				
	,, proposed dividend on ordinary shares for half year @ 12% per annum, making 10% for the year	285 0 0				
	,, balance forward ..	481 9 8				
		£1,456 9 8			£1,456 9 8	
			July 1	By balance c/f	£481 9 8	

If, on the other hand, the debentures are issued at a discount, the company will, of course, receive something less than the full amount for which it will be liable to the debenture-holders, and the amount it loses on the transaction is debited to a "Discount on Debentures Account." The full entries are: (1) A debit to cash of the amount actually received; (2) a debit to discount on debentures account of the difference between the amount received and the full amount of the debentures; and (3) a credit to the debenture account of the nominal amount of the debentures. The debenture account will always have the latter amount to its credit, whatever the terms upon which the debentures have been issued, and this will be the amount of the liability under the head of debentures in the company's balance-sheet. The debit on the discount account must be written off to profit and loss account by the time the debentures become redeemable.

LIABILITIES			
Share Capital:			
Nominal Capital:			
1,000 Ordinary Shares of £10 each		10,000 0 0	
Subscribed and Issued Capital:			
1,000 Shares of £10 each ..		10,000 0 0	
Less 50 shares forfeited		500 0 0	
950		9,500 0 0	
Called and Paid up Capital:			
950 Shares at £5 per share ..			4,750 0 0
Forfeited Shares:			
50 Shares £5 called up		250 0 0	
Less Calls in arrear thereon ..		100 0 0	
			150 0 0
Five per Cent. Mortgage Debentures:			
50 Bonds of £100 each			5,000 0 0
Sundry Creditors:			
On Bills Payable		430 10 6	
,, Open Accounts..		1,651 8 5	
			2,081 18 11
Reserve Fund			500 0 0
Profit and Loss Account:			
Net Profit for Year..		1,456 9 8	
Less Interim Dividend	190 0 0		
Transfer to Reserve Fund.	500 0 0		
		690 0 0	
			766 9 8
			£13,218 8 7

Redemption of Debentures. When debentures are redeemable at a fixed date it is necessary for the company to make provision for paying them off when the time arrives—unless it is in a position to re-borrow the money on favourable terms. One method of doing this is for a sinking fund to be created in the manner previously described in connection with a wasting asset, so that the company's resources shall be equal to the demand when the time arrives for payment. If the debentures are repayable at a premium, care must be taken that the instalments set aside and invested periodically are sufficient to accumulate enough to pay both principal and premium. Other methods of providing for the payment of redeemable debentures are: (1) The purchase of debentures on the market if the price is favourable; or (2) the taking out of a policy of insurance for an amount sufficient to repay the debentures at the due date. Under the latter method the amount of the premium would represent the sinking fund instalment; there would be no risk of loss from the depreciation of the sinking fund investments, and the company would be saved the trouble of periodically investing the instalments and the accruing interest.

Annual Summary of Capital. Every limited company having its capital divided into shares is required to furnish each year a summary of its capital and return of its members in a form prescribed by the Board of Trade. The particulars comprise the nominal capital and how it is divided, the number of shares taken up—distinguishing between those issued credited as fully paid, and those to be paid in cash—the amount per share called up, and the total sum received, the total amount credited as paid on the shares not issued for cash, the amount of unpaid calls, and the amount received on forfeited shares. The summary must give the amount of debt due by the company in respect of debentures and floating charges on its property. The name, address, description, and share holding of each member must be given in detail, as well as a list of the directors.

Besides companies limited by shares, there is a class of company in which the members do not contribute the capital during the company's existence. This kind of company is useful in concerns of a non-trading character, such as professional societies and chambers of commerce, where incorporation is desirable but no working capital is required. These companies are said to be limited by guarantee, because the members guarantee to subscribe a certain limited amount for the purpose of paying the debts if the company be wound-up. There is no peculiarity in the accounts of these companies calling for notice in this chapter.

Double-account System. In addition to companies incorporated under the Companies Consolidation Act, many companies are brought into existence by special Act of Parliament. These companies are, as a rule, formed for the purpose of carrying out works of a public nature such as railways, gas and water works, canals, electric light and power undertakings, etc. For such companies a special system of accounts has been laid down, which is known as the double-account system. It must not be supposed by the reader that this is another name for the double-entry system. All our accounts so far have been upon double-entry principles, and the double-account system is merely an adaptation of those principles for the purpose of showing

clearly a certain set of facts. It has been sufficient hitherto to state the whole position of a firm or company in a single statement called a balance-sheet, which includes the whole of the assets and liabilities of the concern of whatever sort or kind. Accounts kept on those lines are said to be kept on the single-account system, since one account shows the whole position, but this must not be confused with the so-called "system" of single entry.

From the nature of the companies named above it will be seen that their objects are the construction or acquisition of particular works which, when acquired or constructed, will be used for the purpose of earning revenue for the proprietors. They trade in a sense, but not by buying a commodity at one price and selling at another.

Capital Account. The particular object of the double-account system is to show clearly the amount of capital that has been raised for the purpose of the undertaking and how that amount has been expended upon purchasing or constructing the fixed assets—*i.e.*, the property which will, subject to wear and tear and depreciation, always exist for the purpose of earning revenue. With this object a statement is prepared in tabular form showing the character of the capital raised and the manner in which it has been applied. The above is a specimen of such a statement in the case of a gas company, and will enable the reader to see how the object of the system is attained.

THE OLDTOWN GAS COMPANY, LIMITED.

Dr. Capital Account for the Year ended 30th June, 1905. *Cr.*

	Expenditure to 30th June, 1904.	Expended during the Year.	Total to 30th June, 1905.
To Expenditure to 30th June, 1904	249,867	—	249,867
,, Lands acquired			
,, New Buildings, Manufacturing Plant, Machines, Storage Works, and other structures connected with *manufacture*		6,826	
,, New Mains and Service Pipes (not in place of old ones), including laying same, paving, and other works connected with *distribution*		4,754	
,, New Meters (not in place of old ones)		536	12,116
Total Expenditure			261,983
,, Balance of Capital Account (carried to General Balance Sheet)			18,017
			£280,000

	Receipts to 30th June, 1904.	Received during the Year.	Total Receipts to 30th June, 1905.
By Ordinary Shares of £5 each	50,000	—	50,000
,, 2nd Preference Shares of £5 each	40,000	10,000	50,000
,, 1st Preference Shares of £10 each	50,000	10,000	60,000
,, Debenture Stock	120,000	—	120,000
	260,000	20,000	280,000
			£280,000

Only the balance of this account is carried into the company's general balance-sheet, which also shows, on the liabilities side, the amount to the credit of the profit and loss account, the reserve fund, the depreciation fund (which will be explained later), and the general floating liabilities of the company. On the assets side appear the floating assets of the concern, such as cash in hand and at the bank, the stocks of coals, coke, tar, and other products, debts due from persons to whom gas, coke, etc., have been supplied, and any other assets, other than the fixed assets, which the company may possess.

Revenue Account. A detailed revenue account is prepared showing on the one side the income arising from (1) sales of gas; (2) sales of residual products, such as coke, tar and breeze; (3) rents; (4) other items, such as fittings, discounts, etc. On the debit side appear the various expenses under the heads of (1) manufacture of gas, including materials, wages, repairs, etc.; (2) distribution of gas, including salaries, repairs of mains, pipes, and meters; (3) rent, rates and taxes; (4) management expenses and, lastly, miscellaneous items.

The effect of this arrangement of the capital account and the general balance-sheet is that it is necessary to examine both those statements in order to obtain full information as to the assets and liabilities of the concern. Another result of preparing accounts on this system is that the fixed capital assets are shown at cost in the published statements instead of at their actual values. Any repairs and renewals are made out of current revenue and not out of capital moneys, while any extensions and additions are properly provided out of money raised for the purpose and charged as capital outlay in the capital account, as shown above.

Depreciation Fund. Although the fixed assets are set out in the capital account at cost, proper provision is made for wear and tear and depreciation by an amount being charged annually in the profit and loss account in this respect. The amount is not written off the book value of the assets but is carried to the credit of a special account entitled "Depreciation Fund Account," or some other equally distinguishing title, and included in the general balance-sheet under that head. The effect is that, taking the capital account and the general

balance-sheet as a whole, the position of the company is accurately stated; as, although the assets are shown at more than their actual value, this is rectified by the inclusion on the liabilities side of the amount of the depreciation which has taken place and which would, in accounts kept on ordinary single - account (not single entry) lines, be deducted from the assets on the other side of the balance-sheet.

Fixed and Floating Liabilities. Attention has already been directed to the fact that the assets may be divided into two classes—*viz.*, fixed and floating assets. The separation of the capital account from the general balance-sheet, which takes place under the double-account system, emphasises the fact and further makes it clear that a similar division may be made in the case of the liabilities, those of a fixed nature being the share capital of the concern and loans on debentures or mortgages, while the floating liabilities are those to creditors supplying stores, materials, etc., or for unpaid dividends or interest, the indebtedness to whom is discharged practically immediately.

It may be stated that the broad principle of the double-account system is the division of the assets and liabilities into two classes—fixed and floating—the former being included in the capital account, the latter in the general balance-sheet.

Capital and Revenue. A further point to which attention is called by the double-account system is one not specifically dealt with hitherto; that is, the distinction between capital and revenue items. The receipts of a business are generally of such a nature that their classification is an easy matter, and the distinction is quite apparent; but in the event of there being a doubt as to the nature of a particular item, it must be carefully examined, and credit must not be taken for it as income unless it is clear that it can fairly be regarded as revenue of the concern. The question whether an amount should be treated as revenue or capital usually arises in connection with expenditure. The principles upon which a decision should be come to are quite clear, but their application is sometimes a matter of some doubt. The broad rule is that expenditure on the acquisition or construction of property which is to be used to earn revenue, or expenditure which adds to the value of property already acquired, is capital expenditure, and may be debited to an asset account, while outlay, such as repairs and renewals, which merely maintains property at its book value cannot be so treated, but must be regarded as an expense of carrying on the business. The question frequently arises in connection with the purchase of new plant or machinery which may be either wholly or in part in replacement of old assets of the same nature. So far as the new plant, etc., is in replacement of something already standing in the books as an asset, the cost must be treated as a revenue charge and debited to the profit and loss account; but if any part of the expenditure is upon additional plant which will increase the actual value beyond the amount appearing in the books, the proper course is to debit such increase to the asset account, and not allow the charge to fall against revenue.

With regard to amounts received, any doubts concerning their nature will probably arise in connection with the sale of part of an asset. For instance, a patent may be standing in the books of a concern at its cost of £500. A half-share is sold for £1000. There are at least three ways of dealing with this transaction. One is to write off the whole cost of the patent and treat only £500 of the sale price as profit. The second is to retain the remaining half at its present value of £250, and treat £750 of the price as profit. The third method would be to treat the second half as worth as much as the first had sold for, and increase its value in the books accordingly. The result under this method is that credit is taken for the whole £1000 received for the half-share, and for a further £500 in respect of the increased value of the remaining half. This is not desirable, and the fairest basis is the second method.

Income Tax. A matter that is a cause of some worry and annoyance to a trader or to the secretary of a trading company is the annual return to be made for income tax purposes. Income tax is a charge levied annually upon net profits derived from sources in the United Kingdom or paid to residents therein. It is intended to be charged on income from all sources, and the various kinds of income are classified under schedules distinguished by letters of the alphabet. Thus, Schedule A relates to income derived from the ownership of land and buildings, and is borne by the owner, although paid in the first instance by the occupier. It is known as the property or landlord's tax, and when collected by the authorities from a tenant may be deducted by him from his next payment of rent. Schedule B is borne by the occupier and relates to the income from farms, etc. Schedule C has reference to income from public funds, and is generally deducted before the income is paid to the recipient. Schedule E relates to salaries and emoluments paid to persons in the employ of the State, public bodies, companies, etc. Schedule D is the important schedule from the point of view of accounts, since it relates to the profits arising from the carrying on of trade, manufacture, and business generally. The rate of the tax for each schedule is so much in the pound, and is fixed annually by the Finance Act. The amount of tax payable depends upon the amount which has been fixed by the surveyor of taxes as the income of the trader for a particular year. The amount of income is fixed, or, as it is termed, assessed, upon the basis of a return which has to be made each year in or about the month of June. The tax is payable annually on January 1st, and is in respect of the year ending on April 5th following.

Assessment under Schedule D. In the spring of each year a form is sent by the local assessor to persons and firms in his district requiring them to make a return of their income for purposes of assessment. When

returning the form the trader has to make a declaration that the amount stated as liable to tax is correct. The penalty for making a false return is £50 and treble the duty chargeable. The amount returned is based upon the average of the three complete years preceding the year of assessment. Thus, in making a return for the year 1906–7—*i.e.*, ending on April 5th, 1907, a trader whose books are balanced on June 30th in each year would base his return upon his profits for the years ending June 30th, 1903, 1904, and 1905 respectively. Where a business has not been carried on for as long as three years, the return will be based upon the period during which the business has been established.

Towards the end of the year the surveyor issues the notices of assessment. They are sent to all affected persons in his district whether they have made returns or not. If the amount at which the trader is assessed agrees with the amount he returned, he need take no steps, but will wait until he receives a demand for payment, about December, and then pay the tax. If, however, the assessment exceeds the amount on which he considers he should be called upon to pay, he must take steps to appeal to the income tax commissioners. To do this with any hope of success he must be prepared with accounts substantiating his contention as to the proper amount of his income, and he should also be ready to produce his books if required; for, although their production cannot be enforced by the commissioners, a refusal will probably result in the surveyor's assessment being upheld. The return originally sent in should, of course, have been made from accounts prepared for the purpose, and if that was the method adopted those accounts should be forwarded to the surveyor. It may be that he will be satisfied with the production of the accounts. If he is, no further attendance will be necessary, for he will arrange with the commissioners for a reduction of the assessment.

Accounts for Surveyor. It is obvious that a trader will be well repaid for the careful preparation of his accounts for income tax returns at the outset. In order that the accounts shall be prepared upon a proper basis it is necessary that he should know which items in the nature of expenses will be allowed to be

The profits of John Smith, an ironmonger, as shown in his books, were, for the year 1903, £863; 1904, £210; 1905, £587.

Before arriving at these profits the following items had been charged or credited in his profit and loss accounts:	1903	1904	1905
	£	£	£
Interest on capital	250	260	270
Interest on mortgage of freehold premises	90	90	90
Bad debts	60	300	70
Salaries and wages	720	800	780
Rates	75	80	80
Bank charges and interest on overdraft	30	29	31
Repairs of machinery and premises	50	120	20
Depreciation of plant and machinery	75	70	65
Depreciation of freehold premises	50	48	46
Proprietor's salary	250	250	250
Income Tax, Schedule D	48	45	38
Carriage and packing	30	28	30
Rents from two houses belonging to him	55	55	55
General trade expenses	90	120	80
Income Tax, Schedule A, @ 1s. in the £ on freehold premises	10	10	10

The amount upon which he should be assessed under Schedule D for the year 1906–7 is arrived at as follows:

	1903	1904	1905
Profits as shown in books	863	210	587
Add:			
Items charged but not allowed for income tax purposes:			
Interest on capital	250	260	270
Interest on mortgage	90	90	90
Depreciation of freehold premises	50	48	46
Depreciation of plant and machinery	75	70	65
Proprietor's salary	250	250	250
Income Tax, Schedule D	48	45	38
Income Tax, Schedule A	10	10	10
	1,636	983	1,356

Deduct:	1903.	1904.	1905.			
	£	£	£			
Amount of assessment of freehold premises	200	200	200			
Rents of houses (not arising from trading)	55	55	55			
Wear and tear of plant and machinery (say)	50	52	54			
Premiums paid for life insurance (not shown in books of business)	70	70	70	375	377	379
				£1,261	606	977

£1,261 + £606 + £977 = £2,844. Average liable to tax £948.

deducted from his trading profits and which will not, for some of the charges properly made by a trader when preparing his profit and loss account and arriving at his net profit are not allowed to be charged for income tax purposes. On the other hand, there are a few items of profit or income which a trader need not bring in to his account for those purposes. Speaking generally, all charges and expenses necessarily incurred in earning the income of a concern are allowed, but nothing else.

The following are some of the principal items not allowed to be deducted from gross profits in arriving at the taxable income: 1. Losses not arising from trading. 2. Interest on capital. 3. Partners' salaries. 4. Interest on loans. 5. Ground rent. 6. Depreciation of land, buildings, leases, patents. 7. Income tax. 8. Reserve and sinking funds. Tax should be deducted from items of the nature of 4 and 5 when paying the amounts, the effect thus being that the tax is actually borne by the recipient of the payment.

Items to be Deducted from Gross Profits. The following items, *in addition to the usual trade charges*, are allowed: 1. If the premises are the freehold of the trader and, therefore, no rent is paid, he is, nevertheless, allowed to debit the amount of the assessment, the reason being that he has already been charged tax under the head of Schedule A. 2. Repairs as distinct from additions. 3. Estimated doubtful debts. 4. Life insurance premiums up to one-sixth of income. 5. Loss of stock by fire, after taking into account compensation received from an insurance company. 6. Bank interest and charges, because the banker pays the tax. With regard to rent of the trade premises, when they are not his own, he is allowed to charge the amount of the net assessment under Schedule A whether it is in excess of the rent actually paid or not.

Wear and tear of plant and machinery is also allowed, and the rate of allowance is in the discretion of the surveyor. It has already been pointed out that "depreciation" and "wear and tear" are not synonymous terms, and this must be remembered for income tax purposes, as only the latter is allowed. It must be borne in mind that the items enumerated are not the only charges that are allowed. They have been specially mentioned because of their slightly exceptional character, but all losses and expenses necessarily incurred in carrying on the business may, in ordinary circumstances, be charged under the heading of allowances.

Exemption and Abatement. Two further points should be mentioned before proceeding to give an illustration of the making of a return in a concrete case, (*a*) the tax is a personal one, and (*b*) it is levied as far as possible at the source of the income. Point (*a*) is of importance in the case of a partnership, for certain exemptions and abatements are allowed in respect of incomes under £700 per annum. No tax is payable on incomes below £160. An abatement of £160 is allowed on incomes between £160 and £400; that is, a person with an income of £350 would only be required to pay tax on £190. An abatement of £150 is allowed between £400 and £500; an abatement of £120 is allowed between £500 and £600; an abatement of £70 is allowed between £600 and £700. Persons with incomes over £700 per annum pay tax on the full amount. As the tax is personal, partners in a firm have the right to be separately assessed. Therefore, in the case of a partnership where the net profits are £1200 per annum, and there are three partners sharing equally, they will be entitled to be assessed on an income of £400 each, and so entitled to an abatement of £160 each.

Repayment. With regard to the second point, as the tax is levied at the source of the income, limited companies earning profits are charged upon the full amount thereof, no abatement being allowed to them. It frequently happens, therefore, that a person who receives his income from investments in stocks and shares, and whose total income is such as to entitle him to exemption or abatement, is in the position of having had tax deducted before his income reached him. In such a case, and, in fact, in any instance where tax has been wrongly paid or deducted, a claim for repayment must be made to the surveyor.

The Finance Acts of 1907 and 1909. An important concession to the commercial community, and to every taxpayer whose income is "earned," was made by the Finance Act, 1907. That Act provides for a differentiation between earned and unearned incomes, and tax is payable at a lower rate on the former than on the latter. Thus, for the year ended April 5, 1914, the rate for earned incomes is 9d. in the £; but for unearned incomes it is 1s. 2d. Any person desiring to be taxed at the lower rate must make a claim for differentiation before September 30 in each year. The lower rate is only allowed in cases where the total income does not exceed £2000, and is only allowed in respect of the earned portion of the income. A further relief is given under the Finance Act of 1909 to persons whose total income is less than £500. They are entitled to a deduction of £10 from their assessment for each child under sixteen years of age.

As against the reliefs granted by the Acts of 1907 and 1909, the latter Act imposed a super-tax of 6d. in the £ on persons whose incomes exceed £5000. This additional tax is payable on that part of the income which exceeds £3000, so that a person whose income is £5500 pays at the rate of 1s. 2d. on the whole of it, and an additional 6d. in the £ on £2500.

When working examination papers which require the amount of the tax payable to be stated, candidates must be careful to take into consideration the differentiation between earned and unearned incomes, and also the question of super-tax when the income of any individual exceeds £5000.

J. F. G. PRICE

A Special Dictionary explaining Commercial Terms and Phrases appears at the end of the Self-Educator

Clock Problems. Time and Work. Miscellaneous Problems. Duodecimals. Conversion of Ordinary into Duodecimal Measures.

MISCELLANEOUS PROBLEMS

CLOCK PROBLEMS

168. Consider the motion of the hands of a clock. In one hour's time the long hand goes completely round the dial—*i.e.*, passes over sixty minute-spaces, while the short hand only passes over five minute-spaces. Thus the long hand passes over $60-5$, *i.e.*, 55 more spaces in an hour than the short hand does.

Example 1. At what time between 1 and 2 o'clock are the hands of a clock directly opposite one another?

At 1 o'clock the long hand is 5 minutes *behind* the short hand. When the hands are opposite, the long hand will be 30 minutes *ahead* of the short hand.

Therefore, the long hand must gain $5+30 = 35$ spaces on the short hand. But it gains 55 spaces in 60 minutes. Hence we have the proportion

55 : 35 :: 60 minutes : required time.

Therefore, Time

$$=\frac{60\times\cancel{35}^{\,7}}{\cancel{55}_{\,11}}=\frac{420}{11}=\underline{38\tfrac{2}{11}\text{ min. past 1 } Ans.}$$

Example 2. When will the hands be at right angles, between 4 and 5 o'clock?

At 4 o'clock the long hand is 20 minutes behind the short hand. When the hands are at right angles, it must either be 15 minutes *behind* the short hand, or 15 minutes *ahead*. Therefore it must either gain $20-15$ or $20+15$ minutes, *i.e.*, 5 or 35 minutes. As in Example 1, we find that to gain 5 minutes, it takes

$$\frac{60\times 5}{55}\text{ min.}=\frac{60}{11}=5\tfrac{5}{11}\text{ min.}$$

And, since $7\times 5 = 35$, it will take $7\times 5\frac{5}{11}$ minutes, or $38\frac{2}{11}$ minutes to gain 35.

Thus, the required times are $5\frac{5}{11}$ minutes past 4 and $38\frac{2}{11}$ minutes past 4 *Ans.*

Other forms of clock questions, such as "at what time, between two stated hours, are the hands coincident," or "at what time are they any stated number of minutes apart," are worked in the same way.

169. Questions involving two clocks are generally simple applications of the principle of Art. 165.

Example. Two clocks show the correct time at 9 a.m. on August 12. The one loses 8 seconds, and the other gains 12, in 24 hours. When will one clock be 5 minutes ahead of the other, and what time will each clock then show?

At the end of 24 hours the clocks are $8+12 = 20$ seconds apart. Therefore, they will be 5 minutes, or 300 seconds apart after $\frac{300}{20}\times 24$ hours, *i.e.*, 15 days.

Thus, one is 5 minutes ahead of the other at 9 a.m. on August 27. Also, in 15 days the first clock loses 15×8 seconds $= 120$ seconds $=$ 2 minutes, so that at 9 a.m. on August 27 this clock points to 8.58. The other clock is 5 minutes ahead of this—*i.e.*, at 9.3.

TIME AND WORK

170. The fundamental principle here is

Work done per day × Number of days = Total to be done.

Example 1. A can do a piece of work in 6 days which B could do in 8 days. How long will they take over it if they both work together?

Find the amount done per day, thus:

A does the whole piece in 6 days.

Therefore, A does $\frac{1}{6}$ of the piece in 1 day.

Similarly, B does $\frac{1}{8}$ of the piece in 1 day.

Therefore, working together, they do $\frac{1}{6}+\frac{1}{8}$ of the piece in 1 day $=\frac{4+3}{24}=\frac{7}{24}$ of the piece in 1 day.

Hence, they do $\frac{1}{24}$ in $\frac{1}{7}$ of a day, and therefore $\frac{24}{24}$, or the whole piece, in $\frac{24}{7}$ days, *i.e.*, $3\frac{3}{7}$ days *Ans.*

Example 2. A bath which holds 21 gallons can be filled by the cold water tap in 6 minutes, and by the hot water tap in 7. The waste-pipe can empty it in 3 minutes. If the bath is filled, and then all three pipes are opened, how much water will be left in the bath at the end of half an hour?

The waste-pipe empties the bath in 3 minutes.

Therefore, it empties $\frac{1}{3}$ of it in 1 minute.

Similarly, the cold-water tap fills $\frac{1}{6}$ in 1 minute, and the hot-water tap fills $\frac{1}{7}$ in 1 minute.

Therefore, when all three are open $\frac{1}{3}-\frac{1}{6}-\frac{1}{7}$ is emptied in 1 minute, *i.e.*, $\frac{14-7-6}{42}=\frac{1}{42}$ is emptied in 1 minute.

Hence, after half an hour, $30\times\frac{1}{42}$ or $\frac{5}{7}$ of the bath is emptied.

Therefore, there remains in the bath $(1-\frac{5}{7})$ of 21 gallons $=\frac{2}{7}$ of $21 =$ 6 gallons *Ans.*

Example 3. A and B agree to do a piece of work for 30s. A could do the work alone in 5 days, and B could do it alone in 6 days. But, with the help of C, they finish the work in 2 days. How should the money be divided?

A can do $\frac{1}{5}$ of the work in 1 day, so that in the 2 days which they work he does $\frac{2}{5}$.

Similarly, B does $\frac{2}{6}$, or $\frac{1}{3}$ of the work.

Hence, C does the remainder—*viz.*, $1-\frac{2}{5}-\frac{1}{3}$ of the work $=\frac{4}{15}$ of the work.

Therefore,

$$\left.\begin{array}{l}\text{A should have } \tfrac{2}{5} \text{ of 30s.} = \text{12s.}\\ \text{B should have } \tfrac{1}{3} \text{ of 30s.} = \text{10s.}\\ \text{C should have the remaining 8s.}\end{array}\right\}\ \underline{Ans.}$$

EXAMPLES 20

1. A starts 3 minutes after B for a place $4\frac{1}{2}$ miles distant. B, on reaching his destination, immediately returns, and, after walking a mile, meets A. If A's rate is 1 mile in 18 minutes, how many miles an hour does B walk ?

2. A train passed a station 40 miles away 2 minutes late. If it had travelled at 50 miles an hour, it would have been 10 minutes late. Find the rate of the train.

3. A man rows $\frac{3}{4}$ mile up-stream in half an hour. If there had been no current he would only have taken a quarter of an hour. How long will he take to row back again ?

4. A man drives to a certain town at 8 miles an hour. He returns by a road 2 miles longer, at 10 miles an hour. The return journey takes 12 minutes less than the outward journey. How long is each road ?

5. A person standing on a railway platform, which was 88 yards long, noticed that a train took 9 seconds in passing him, and took 21 seconds in passing through the station. How long was the train, and at what rate was it travelling ?

6. A man travelling 9 miles per hour is followed, 4 minutes later, by a man travelling 10 miles an hour. When and where will the second man overtake the first ?

7. A walks from one town to another at 4 miles an hour. At the halfway, he is overtaken by B, who walks 5 miles an hour. A now quickens to B's rate and finds that he arrives at his destination 15 minutes earlier in consequence. How far is it between the two towns ?

8. There are two candles, P and Q, one of them 1 inch longer than the other. P is lighted at 4.30, and Q at 6 o'clock. At 8.30 they are both the same length. P burns out at 10.30 and Q at 10. What were the original lengths ?

9. A and B do a piece of work in a certain time. If each had done half the work, A would have had to work one day less, and B two days more, than they actually did work. How long did they take, when they worked together ?

10. At noon on Monday a clock is 2 minutes fast, and at 8 a.m. on the following Wednesday it is 1 minute slow. When was it right ?

11. At what time between 5 o'clock and 5.30 are the hands of a watch 14 minutes apart ?

12. I row against a stream flowing $1\frac{1}{2}$ miles per hour to a certain point, and then turn back, stopping 2 miles short of my original starting-place. If the whole time occupied is 2 hr. 10 min., and in still water I row $4\frac{1}{2}$ miles per hour, how far up-stream did I go ?

13. A hare is 60 of her own leaps in front of a greyhound, and takes 3 leaps while the hound takes 2. But the hound goes as far in 3 leaps as the hare does in 7. In how many leaps will he catch the hare ?

14. Two cyclists start to meet each other. One rode 2 miles an hour faster than the other, and they met in $1\frac{1}{2}$ hours. If each had travelled 2 miles per hour faster than he did, they would have met in $1\frac{1}{4}$ hours. Find the distance between the starting-places.

MISCELLANEOUS EXAMPLES

171. The following are types of examples which occur frequently.

Example 1. In what proportion must tea at 1s. 6d. per lb. be mixed with tea at 2s. 4d. per lb. in order that the mixture may be worth 1s. 9d. per lb. ?

1 lb. of the cheaper tea is worth 3d. *less* than 1 lb. of the mixture.

1 lb. of the dearer tea is worth 7d. *more* than 1 lb. of the mixture.

Hence, 7 lb. of the cheaper tea must be mixed with 3 lb. of the dearer tea. For 7 lb. of the cheaper will be worth 7×3d. = 21d., *less* than 7 lb. of the mixture, and 3 lb. of the dearer will be worth 3×7d. = 21d. *more* than 3 lb. of the mixture ; so that, together, they have the same value as 10 lb. of the mixture.

The required proportion is therefore 7 : 3 *Ans.*

Example 2. A man distributed £1 16s. 10d. amongst 85 children ; each girl received 4d. and each boy 6d. How many girls were there ?

If each child received 4d., the man would spend 85×4d. = £1 8s. 4d. This is 8s. 6d. too little.

If each received 6d., he would spend 85×6d. = £2 2s. 6d., which is 5s. 8d. too much.

Hence,

No. of girls : No. of boys :: 5s. 8d : 8s. 6d.
:: 68 : 102

Therefore, the number of girls

$$\frac{68}{68+102} \text{ of } 85 = \frac{2}{5} \text{ of } 85 = 34 \ \textit{Ans.}$$

A question of this sort, however, need not be treated as a "mixture" problem. For, after each child has received 4d., the man is left with 8s. 6d., which he uses to give an extra 2d. to each boy. Now, 8s. 6d. contains 51 twopences. Hence, there are 51 boys, and therefore $85 - 51$, or 34 girls.

Example 3. A person has to buy a certain number of oranges for a certain sum of money. If he buys at the rate of 3 a penny, he spends 8d. too much, and at the rate of 4 a penny he spends 1s. too little. Find the sum of money.

At the first rate an orange costs $\frac{1}{3}$d.

At the second rate an orange costs $\frac{1}{4}$d.

The difference $= \frac{1}{3} - \frac{1}{4} = \frac{1}{12}$d.

Hence, by paying $\frac{1}{12}$d. less for each orange, he reduces the total cost by 8d. + 1s., or 20d.

Therefore, the number of oranges = 20d. $\div \frac{1}{12}$d. = 240.

Now 240 oranges at 4 a 1d. cost 60d., or 5s., and this is 1s. less than the sum he has to spend. Thus, the required sum is 6s. *Ans.*

We have the same principle in the following :

A man walks to the station at 4 miles an hour and arrives 5 minutes late. Had he walked at 5 miles an hour he would have been 4 minutes too early. How far is it to the station ?

The first rate is 1 mile in 15 minutes, and the second is 1 mile in 12 minutes. Thus, by taking

3 minutes less over each mile, he takes 9 minutes less for the whole distance. The distance is therefore 9 ÷ 3, or 3 miles.

Example 4. A mixture of 280 gallons of spirit and water contains 70 per cent of spirit. How much spirit must be added in order to raise the proportion to 84 per cent. ?

Amount of water in the mixture = 30 per cent. of 280 gallons = 84 gallons.

After more spirit has been added, this 84 gallons of water forms (100 − 84) or 16 per cent. of the mixture. Hence, the total amount of mixture will then be $\frac{100}{16}$ of 84 gallons, *i.e.*, 525 gallons.

Therefore, the amount of spirit to be
= 525 − 280 = 245 gallons *Ans.*

Example 5. I look at my watch between 5 and 6 o'clock. On looking again between 6 and 7 o'clock I find that the hands have exactly changed places. What was the time when I first looked ?

In a question of this sort, the chief point is to find what distance the hands are apart. Once this distance is known, the rest of the problem is worked in the same way as already explained in Art. **168**.

We know that the long hand moves through 60 minute-spaces while the short hand moves through 5—*i.e.*, in any given interval, the long hand moves through 12 times the distance through which the short hand moves.

Now, in the above problem, the distance through which the short hand moves is equal to the distance between the hands. The long hand, therefore, moves through 12 times this distance. Hence, if the long hand had moved on into the position now occupied by the short hand, it would have moved through 12 + 1, or 13 times the distance between the hands. But the long hand has now moved from a certain position which it occupied between 5 and 6 o'clock into the same position between 6 and 7 o'clock, *i.e.*, through 60 minute-spaces.

Therefore, 60 minutes = 13 times the distance between the hands ; so that the distance between them is $\frac{1}{13}$ of 60 minutes, or $4\frac{8}{13}$ minutes.

We have now, by the method of Art. **168**, to find " at what time between 5 and 6 o'clock is the long hand $4\frac{8}{13}$ minutes ahead of the short hand ? "

At 5 o'clock the long hand is 25 minutes behind the other. It has therefore to gain $25 + 4\frac{8}{13}$, or $29\frac{8}{13}$ minutes.

Hence,

$55 : 29\frac{8}{13} :: 60$ minutes : reqd. time.

Therefore,

$$\text{Reqd. time} = \frac{\overset{12}{\cancel{60}} \times \overset{35}{\cancel{385}}}{13 \times \underset{\cancel{5}}{\cancel{55}}} = \frac{420}{13}$$

$= 32\frac{4}{13}$ minutes past 5 *Ans.*

DUODECIMALS

172. In finding the area of a rectangle by the method of Art. **153**, or the volume of a rectangular solid by that of Art. **158**, it is necessary to express every dimension in terms of the same unit. We have to reduce every dimension to yards, or to feet, or to inches, before working the multiplication. This, however, need not be done if we adopt the method of *Duodecimals*.

The foot is the unit of the system. The unit is divided as follows.

A *linear prime* is one-twelfth of a foot.

A *superficial prime* is one-twelfth of a square foot.

A *cubic prime* is one-twelfth of a cubic foot.

A second, linear, superficial, or cubic, is one-twelfth of the corresponding prime.

A *third* is one-twelfth of a second, and so on.

A prime, whether linear, superficial, or cubic, is denoted by 1′. Similarly, a second is denoted by 1″, a third by 1‴.

173. It is clear from the definitions that

(i.) A linear prime = $\frac{1}{12}$ ft. = 1 in.
A linear second = $\frac{1}{12}$ in.

(ii.) A superficial prime = $\frac{1}{12}$ sq. ft. = 12 sq. in.
A superficial second = $\frac{1}{12}$ of 12 sq. in. = 1 sq. in.
A superficial third = $\frac{1}{12}$ sq. in.

(iii.) A cubic prime = $\frac{1}{12}$ cubic ft. = 144 cubic in.
A cubic second = $\frac{1}{12}$ of 144 cubic in. = 12 cubic in.
A cubic third = $\frac{1}{12}$ of 12 cubic in. = 1 cubic in.

We can thus convert duodecimal measures into ordinary measures. For example,

5 ft. 3′ 7″ = 5 ft. $3\frac{7}{12}$′ = 5 ft. $3\frac{7}{12}$ in.

7 sq. ft. 5′ 9″ = 7 sq. ft. (60 + 9) sq. in. = 7 sq. ft. 69 sq. in.

4 cubic ft. 3′ 8″ 5‴ = 4 cubic ft (432 + 96 + 5) cubic in. = 4 cubic ft. 533 cubic in.

Similarly, we can convert ordinary measure into duodecimals.

4 yd. 1 ft. $3\frac{1}{4}$ in. = 13 ft. $3\frac{3}{12}$ in. = 13 ft. 3′ 3″.

2 sq. yd. 5 sq. ft. 98 sq. in.

$= 23 \text{ sq. ft.} + \frac{96 + 2}{144} \text{ sq. ft.}$

$= 23 \text{ sq. ft.} + \frac{8}{12} \text{ sq. ft.} + \frac{2}{144} \text{ sq. ft.}$

= 23 sq. ft. 8′ 2″

3 cu. ft. $123\frac{1}{2}$ cu. in.

$= 3 \text{ cu. ft.} + \frac{120}{1723} \text{ cu. ft.} + \frac{3\frac{6}{12}}{1728} \text{ cu. ft.}$

$= 3 \text{ cu. ft.} + \frac{10}{12^2} \text{ cu. ft.} + \frac{3}{12^3} \text{ cu. ft.} + \frac{6}{12^4} \text{ cu. ft.}$

= 3 cu. ft. 10″ 3‴ 6⁗

174. We must now consider the multiplication of duodecimals.

$1 \text{ ft.} \times 1' = 1 \text{ ft.} \times \frac{1}{12} \text{ ft.} = \frac{1}{12} \text{ sq. ft.} = 1$ superficial prime.

$1 \text{ ft.} \times 1'' \quad 1 \text{ ft.} \times \frac{1}{12^2} \text{ ft.} = \frac{1}{12^2} \text{ sq. ft.} = 1$ superficial second.

Similarly, 1 ft. × 1″ 1 superficial third ; and so on.

Again,

$1' \times 1' = \frac{1}{12}$ ft. $\times \frac{1}{12}$ ft. $= \frac{1}{12^2}$ sq. ft. = 1 superficial second.

$1' \times 1'' = \frac{1}{12}$ ft. $\times \frac{1}{12^2}$ ft. $= \frac{1}{12^3}$ sq. ft = 1 superficial third.

Example 1. Find the area of a rectangle which measures 5 ft. 9 in. by 3 ft. 3 in.

$$\begin{array}{ll} 5 \text{ ft.} & 9' \\ \underline{3 \text{ ft.}} & \underline{3'} \\ 17 & 3' \\ 1 & 5'\ 3'' \\ \hline 18 \text{ sq. ft.} & 8'\ 3'' \end{array}$$

$= 18$ sq. ft. $+ (\frac{8}{12} + \frac{3}{144})$ sq. ft.
$= 18$ sq. ft. 99 sq. in. *Ans.*

Explanation. Multiply 5 ft. 9′ by 3 ft. Thus.

3 ft. × 9′ = 27 super. primes = 2 sq. ft. 3′.

Put down 3′ and carry 2 sq. ft. 3 times 5, 15, and 2, 17.

Next, multiply by 3′.

$3' \times 9' = 27''$ super. $= 2'\ 3''$.

Put down 3″, carry 2′.

3′ × 5 ft. = 15′, and 2′ = 17′ = 1 sq. ft. 5′.

On adding the two lines, we get 18 sq. ft. 8′ 3″, which, by the last article, is equal to 18 sq. ft. 99 sq. in.

Example 2. The area of a rectangle is 100 sq. ft. 20 sq. in., and its length is 11 ft. 8 in. Find its breadth.

$$\begin{array}{l} 11 \text{ ft. } 8')100 \text{ sq. ft. } 1'\ 8''(8 \text{ ft. } 7' = \underline{8 \text{ ft. } 7 \text{ in. } \textit{Ans.}} \\ \quad\quad\quad\ \underline{93 \text{ sq. ft. } 4'} \\ \quad\quad\quad\quad 6 \text{ sq. ft. } 9'\ 8'' \\ \quad\quad\quad\quad \underline{6 \text{ sq. ft. } 9'\ 8''} \end{array}$$

Explanation. 20 sq. in. is equal to 1′ 8″. Beginning the division, 11 ft. into 100 sq. ft. appears to go 9 times. But on multiplying 11 ft. 8′ by 9 we get 105 sq. ft., which is too big. Try 8. Then, 8 ft. × 8′ = 64′ = 5 sq. ft. 4′. Put down 4′, carry 5 sq. ft.; 8 ft. × 11 ft. = 88 sq. ft., and the 5 carried make 93. Subtract, saying, 4′ and 9′ make 1 ft. 1′. Put down 9′ and carry 1 ft., etc.

Next 11 ft. into 6 sq. ft. 9′, or 81′, goes 7′. Multiply the divisor by 7′. Thus, 7′ × 8′ = 56″ = 4′ 8″. Put down 8″, carry 4′. Then 7′ × 11 ft., etc.

175. In finding volumes, we shall, of course, have to multiply linear feet, primes, etc., into superficial feet, primes, etc.

We have

1 ft. × 1′ super. = 1 ft. $\times \frac{1}{12}$ sq. ft. $= \frac{1}{12}$ cu. ft. = 1 cu. prime.

1 ft. × 1″ super. = 1 ft. $\times \frac{1}{12^2}$ sq. ft. $= \frac{1}{12^2}$ ft. = 1 cu. second, and so on.

Again,

$1' \times 1'$ super. $= \frac{1}{12}$ ft. $\times \frac{1}{12}$ sq. ft. $= \frac{1}{12^2}$ cu. ft. = 1 cu. second.

$1' \times 1''$ super. $= \frac{1}{12}$ ft. $\times \frac{1}{12^2}$ sq. ft. $= \frac{1}{12^3}$ cu. ft. = 1 cu. third.

Example. Find the volume of a rectangular solid whose dimensions are 6 ft. 5½ in., 5 ft. 7 in., and 3 ft. 4 in.

$$\begin{array}{llll} 5 \text{ ft.} & 7' & & \\ \underline{3 \text{ ft.}} & \underline{4'} & & \\ 16 & 9' & & \\ 1 & 10' & 4'' & \\ \hline 18 \text{ sq. ft.} & 7' & 4'' & \\ \underline{6 \text{ ft.}} & \underline{5'} & \underline{6''} & \\ 111 \text{ cu. ft.} & 8' & 0'' & \\ 7 & 9' & 0'' & 8''' \\ & 9' & 3'' & 8''' \\ \hline 120 \text{ cu. ft.} & 2' & 4'' & 4''' \end{array}$$

= 120 cu. ft. (288 + 48 + 4) cu. in.
= 120 cu. ft. 340 cu. in. *Ans.*

Explanation. Multiply 5 ft. 7′ by 3 ft. 4′, as in Ex. 1 of the last article, obtaining 18 sq. ft. 7′ 4″.

Next, 6 ft. 5½ in. equals 6 ft. $5\frac{6}{12}$ in., or 6 ft. 5′ 6″.

Then, 6 ft. × 4″ = 24″ = 2′, 6 ft. × 7′ = 42′, and 2′ = 44′ = 3 cu. ft. 8′, and so on.

Answers to Arithmetic

Examples 19

1. A square field, of the same breadth as that in the question, would contain 30 acres ÷ 3 = 10 acres = 48400 sq. yd.

Therefore, Breadth of the field $= \sqrt{48400}$ = 220 yd. The length = 3 × 220 yd. = 660 yd.

2. Area of paper required = 2 (17¾ + 13¾) × 10 sq. ft. = 2 × 31½ × 10 sq. ft

$$\therefore \text{ Length required} = \frac{2 \times 31\frac{1}{2} \times 10}{1\frac{3}{4} \times 3} \text{ yd.}$$

Hence,

$$\text{Cost} = £\frac{2 \times 63 \times 10 \times 4 \times 8}{2 \times 7 \times 3 \times 12 \times 3 \times 20} = £1\ 6\text{s. } 8\text{d.}$$

3. Carpet costs 3s. 3d. more per square yard than oilcloth. To cover the whole border with carpet costs £3 18s. more than to cover it with oilcloth. ∴ No. of square yards in the border = £3 18s. ÷ 3s. 3d. = 24 sq. yd. = 216 sq. ft. Area of floor = 21 × 21 = 441 sq. ft. ∴ Area of carpet = 441 − 216 = 225 sq. ft. Side of carpet $= \sqrt{225}$ = 15 ft. Hence, width of the border = (21 − 15) ÷ 2 = 3 ft.

4. Area of the four sides of the cistern = 2 (6 + 4) × 3 = 60 sq. ft. Area of bottom = 6 × 4 = 24 sq. ft. No. of square feet of lead required = 60 + 24 = 84 sq. ft. = 84 × 8 ÷ 112 cwt.

$$\text{Cost} = \frac{84 \times 8 \times 61}{112 \times 6}\text{s.} = 61\text{s.} = £3\ 1\text{s.}$$

5. Each of the walls would be 2 × 1½ = 3 times the area of the corresponding wall in the actual room. The cost would therefore be 3 × £2 17s. 9d., or £8 13s. 3d.

6. No. of square yards in the field = £852 0s. 10d. ÷ 10d. = 20449. ∴ Side of field $= \sqrt{20449}$ yd. = 143 yd. Length of fence required = 4 × 143 yd.

$$\therefore \text{ Cost} = £\frac{4 \times 143 \times 8}{20} = £228\ 16\text{s.}$$

7. A box measuring 7 in. × 5 in. × 3 in. contains 105 cubic in. The given box contains 13125 cubic in. or 105 cubic in. × 125. Therefore, since

the volume of the given box is 125 times that of the other, each dimension of the given box is $\sqrt[3]{125}$, or 5 times, the corresponding dimension of the other. The required dimensions are therefore 35 in., 25 in., and 15 in.

EXAMPLES 20

1. A walks $3\frac{1}{2}$ miles before he meets B. This takes him $3\frac{1}{2} \times 18$ mins., *i.e.*, 63 min. $\therefore$ B walked for $63 + 3 = 66$ min. The distance B walks is $4\frac{1}{2} + 1 = 5\frac{1}{2}$ miles. His rate is therefore $\frac{60}{66}$ of $5\frac{1}{2}$ miles per hour, or 5 miles per hour.

2. Travelling at 50 miles per hour, the train will take $\frac{40}{50}$ of an hour, or 48 min., to go 40 miles. This is 10 min. too long. It should therefore do 40 miles in 38 min. ; and, since it passes the station 2 min. late, it actually does the 40 miles in $(38 + 2)$ min. Hence, its rate is 1 mile per min., or 60 miles per hour.

3. In still water, he rows $\frac{3}{4}$ mile in $\frac{1}{4}$ hour, or 3 miles per hour. Against the stream he rows $\frac{3}{4}$ mile in $\frac{1}{2}$ hour, or $1\frac{1}{2}$ miles per hour. Hence, stream's rate $= 3 - 1\frac{1}{2} = 1\frac{1}{2}$ miles per hour. $\therefore$ His rate down stream $= 3 + 1\frac{1}{2} = 4\frac{1}{2}$ miles per hour. This is 3 times his rate up stream; so that, to return, he will take $\frac{1}{2}$ hour $\div 3$, $= 10$ min.

4. The extra 2 miles of the return journey, at 10 miles per hour, takes $\frac{2}{10}$ of an hour, or 12 min. Hence, had he returned by the first road at 10 miles an hour, he would have taken $12 + 12$, *i.e.*, 24 min. less than for the outward journey. But, at 8 miles per hour, 1 mile takes $7\frac{1}{2}$ min., and at 10 miles per hour, 1 mile takes 6 min. $\therefore$ He takes $1\frac{1}{2}$ min. less over each mile. Since he takes 24 min. less altogether, the number of miles in the first road $= 24 \div 1\frac{1}{2} =$ 16 miles. Return road $= 16 + 2 = 18$ miles.

5. The train passes the man (*i.e.*, goes its own length) in 9 sec. It goes through the station (*i.e.*, goes its own length and another 88 yd.) in 21 sec. $\therefore$ It goes 88 yd. in $21 - 9$, or 12 sec. Its rate, therefore, is 5×88 yd. in 60 sec. $= \frac{1}{4}$ mile in 1 min. $= 15$ miles per hour. Length of the train $=$ distance it goes in 9 sec. $= \frac{9}{12}$ of 88 yd. $= 66$ yd.

6. The first man is 4 min. ahead. *i.e.*, $\frac{4}{60}$ of 9 miles, or $\frac{3}{5}$ mile. The second man gains on him 1 mile per hour. He will, therefore, overtake him in $\frac{3}{5}$ hour, *i.e.*, 36 min. The first man will have been walking $(36 + 4)$ min., and will have gone $\frac{40}{60}$ of 9 miles, *i.e.*, 6 miles.

7. 5 miles per hour $= 1$ mile in 12 min.; 4 miles per hour $= 1$ mile in 15 min. Hence, in the second half of the journey, A takes 3 min. less over each mile. Since he takes 15 min. less altogether, the second half of the journey is $15 \div 3$, or 5 miles. The whole distance is, therefore, 10 miles.

8. P burns as many inches in 2 hours (8.30 to 10.30) as Q burns in $1\frac{1}{2}$ hours (8.30 to 10). P burns for 6 hours (4.30 to 10.30) and Q burns for 4 hours (6 to 10). But P, in 6 hours, burns as much as Q would burn in $4\frac{1}{2}$ hours. Therefore, since one was an inch longer than the other, it is clear that Q was the short candle, and would have burned one more inch in half an hour. Hence, Q, burning 2 in. per hour, burns 8 in. between 6 o'clock and 10. Thus, the required lengths are, P, 9 in., and Q, 8 in.

9. Working together, A does an amount above half the work which occupies him for 1 day. When they work separately, B takes 2 days to do this extra piece. Thus, A does as much in 1 day as B does in 2 ; so that, working together, A does $\frac{2}{3}$ of the whole, and B does $\frac{1}{3}$. Hence, A does $\frac{2}{3} - \frac{1}{2} = \frac{1}{6}$ of the work in a day. $\therefore$ B does $\frac{1}{12}$ of it in a day. Together they do $\frac{1}{6} + \frac{1}{12} = \frac{1}{4}$ of it in a day, or the whole piece in 4 days.

10. Noon on Monday to 8 a.m. on Wednesday is 44 hours. Thus, the clock loses 3 min. in 44 hours. The clock was right when it had lost 2 min., *i.e.*, after $\frac{2}{3}$ of 44 hours, or 29 hours 20 min. This will be 5.20 p.m. on Tuesday.

11. At 5, the large band is 25 min. behind the other. To be only 14 min. behind, it must gain $25 - 14$, or 11 min. on the other. But it gains 55 min. in an hour, so that it gains 11 in $\frac{1}{5}$ of an hour., *i.e.*, 12 min. The required time is 12 minutes past 5.

12. Rate up-stream $= 4\frac{1}{2} - 1\frac{1}{2} = 3$ miles per hour. Rate down $= 4\frac{1}{2} + 1\frac{1}{2} = 6$ miles per hour. $\therefore$ To have come the other 2 miles to the original starting-place would have taken an extra $\frac{1}{3}$ hour, and the total time would be 2 hours 10 min. $+ 20$ min. $= 150$ min. Since it takes twice as long to go up as to come down, the time taken to go up stream $= \frac{2}{3}$ of 150 min. $= 100$ min. $= 1\frac{2}{3}$ hour. Distance $= 1\frac{2}{3}$ of 3 miles $= 5$ miles.

13. The hare takes 3 leaps to the hound's 2, or 9 to the hound's 6. But the hound goes as far in his 6 as the hare goes in 14. The hound, therefore, gains $14 - 9 = 5$ hare's leaps in every 6 leaps he takes. Hence he gains the 60 leaps in 12×6, or 72 of his own.

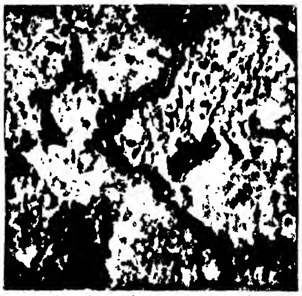
14. In $1\frac{1}{2}$ hours one rides $1\frac{1}{2} \times 2 = 3$ miles further than the other. Hence, they meet $1\frac{1}{2}$ miles beyond half-way. Similarly, at the faster rate, they would meet $1\frac{1}{4}$ miles beyond half-way. Now, if the faster man had again ridden for $1\frac{1}{2}$ hours at the quicker rate, he would have gone $1\frac{1}{2} \times 2$, or 3 miles further than he rides at the slower rate. But in reality, he rides $1\frac{1}{2} - 1\frac{1}{4}$, or $\frac{1}{4}$ mile less than in the first case. Thus, 3 miles $+ \frac{1}{4}$ mile is the distance he would go in the extra $\frac{1}{4}$ hour, *i.e.*, his rate would be 13 miles per hour. But, at 13 miles per hour, he goes $13 \times 1\frac{1}{4}$ miles in $1\frac{1}{4}$ hours, *i.e.*, $16\frac{1}{4}$ miles. This was $1\frac{1}{4}$ miles beyond half-way. Hence, half the distance is 15 miles, and the whole distance 30 miles.

NOTE. In Examples 13, No. 12 (page 1200), for "10 chains of road" read "7 chains of road." The answer given at the foot of the page is then correct.

H. J. ALLPORT

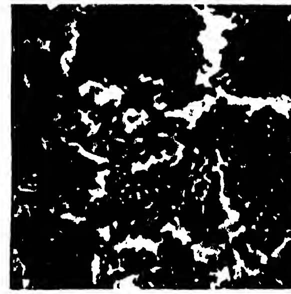
ARITHMETIC CONCLUDED

IRON AND STEEL UNDER THE MICROSCOPE



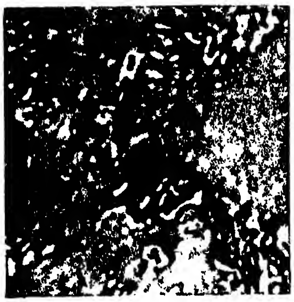
1. Containing 0.18 per cent. carbon

2. Containing 0.722 per cent. carbon

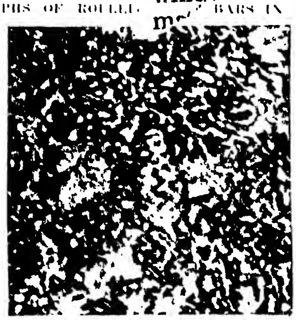


3. Containing 1.306 per cent. carbon

MAGNIFIED PHOTOGRAPHS OF ROLLED BARS IN ORDINARY CONDITION



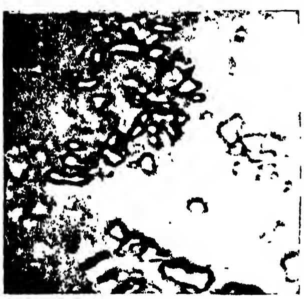
4. Containing 0.18 per cent. carbon



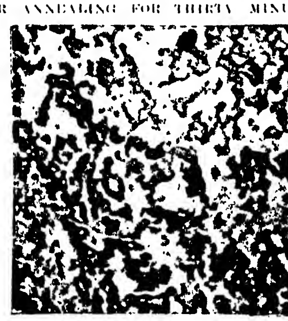
5. Containing 0.722 per cent. carbon

6. Containing 1.306 per cent. carbon

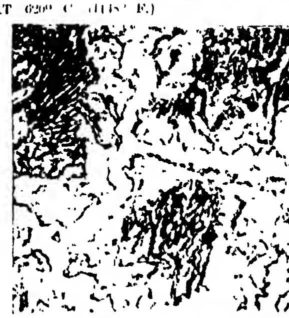
THE ABOVE BARS AFTER ANNEALING FOR THIRTY MINUTES AT 620° C. (1148° F.)



7. Containing 0.18 per cent. carbon



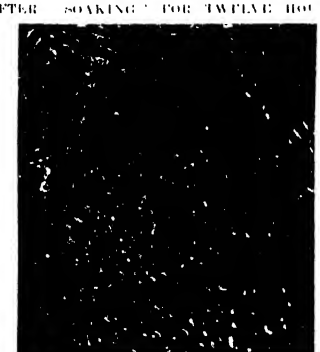
8. Containing 0.722 per cent. carbon



9. Containing 1.306 per cent. carbon

THE ABOVE BARS AFTER "SOAKING" FOR TWELVE HOURS AT 620° C. (1148° F.)

10. Outside of casting



11. Intermediate position

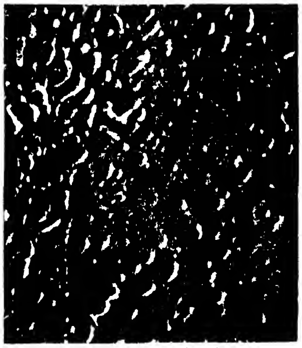
12. Centre of casting

MALLEABLE IRON CASTING

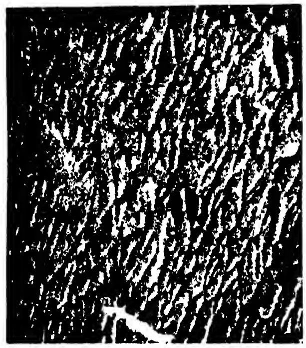
MICROGRAPHIC SPECIMENS OF IRON AND STEEL

The micrographic specimens of metals on this and the following page have the authority of the Mechanical Engineers' Transactions, from which publication they are reproduced. Those appearing on this page are magnified sixteen hundred diameters.

COMMON METALS UNDER THE MICROSCOPE



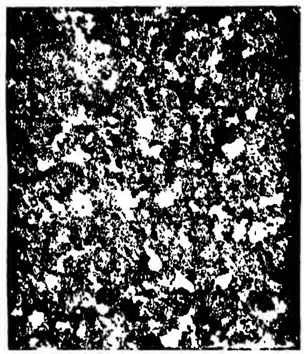
13. Cast copper, magnified 30 diameters



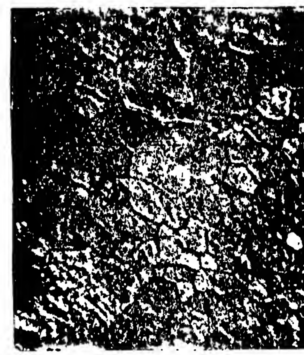
14. Rolled copper, magnified 30 diameters

15. Copper foil, magnified 50 diameters

16. Thin sheet of cast tin, magnified 30 diameters

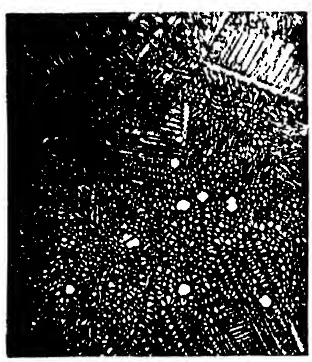


17. Hammered tin, magnified 35 diameters

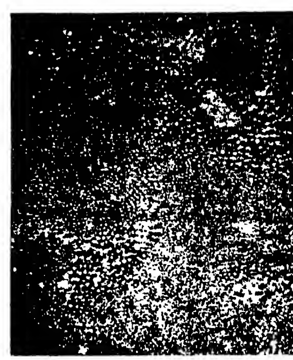


18. Tin nearly melting, magnified 35 diameters

19. Cast zinc, magnified 30 diameters



20. Cast aluminium, magnified 30 diameters



21. Cast lead, magnified 30 diameters

22. Platinum slowly cooled, magnified 30 diameters

23. Cast silver, magnified 30 diameters

24. Gold slowly cooled, magnified 30 diameters

MICROGRAPHIC SPECIMENS OF METALS

The Ladder offered by Modern Industrial Conditions to the Man who Tries. The Best Age for Effort.

THE AGE OF OPPORTUNITY

IT is of little avail, in the present age, to wait for opportunities. Patience of this sort is not so well rewarded as it was in the days when all things moved slowly in the grooves of custom and tradition, and there was little change of method from generation to generation. The man who waits, like Micawber, for something to turn up now often gets left behind No doubt the continual innovations and improvements in the general machinery of life, which are the characteristics of modern civilisation, seem to bring many new avenues to success before the men who are waiting for openings, but the men who win their way to the front are those who do not wait for opportunities, but go in search of them and make them when they cannot find them.

In practically every field of activity, except perhaps the public Civil Services, an able man makes his chances. That is why what some people call the luck of the able man seems at times so marvellous. He wins against overwhelming odds. Starting as an office-boy in some great firm with an organisation so complete that ordinary employees seem enslaved by it, a London man has become in middle age the managing-director of the firm. Capital has not counted in his rise, for he has not been able to save enough money to help in the finance of the business. He has made his way entirely by work of an unusual sort. He has discovered new opportunities for increasing the trade of the firm until the other directors have seen that he was the best general manager they could hope to find.

The career of a great American leader of industry is a still more striking example of the luck of the able man. He is now president of the greatest company in the world —the United States Steel Corporation, with its capital of fifteen hundred million dollars. He began as a common labourer, working twelve hours a day at loading scrap in a wire-mill. But, being one of those men who shape their own destiny, he soon rose to the position of a mechanic, and in 1882 he was working as a wire-drawer. The thoroughness with which he did his work led to his being promoted to the place of a foreman, and by working hard at educating himself he was able to relinquish manual labour and go out as a travelling salesman. Three years of this new kind of experience enabled him to gain the rank of sales manager, from which he climbed to the position of general manager to an important wire company. He built up an unrivalled knowledge of the world-wide conditions of the steel industry, and because of this special knowledge he was selected at 38 to control the export department of the United States Steel Corporation. In 1911, when he was made president of this immense concern, he had increased the export sales by 200 per cent.

So we see that, by active foresight, a common labourer can make himself indispensable to the largest manufacturing concern in the world. It does not, therefore, appear that the growth of the modern system of gigantic corporations prevents a man of ability from making openings for himself in the most powerful of business organisations. Unless a trust had a general control over all the sources of raw material in any important industry, it could not afford to neglect the men with the priceless creative faculty. If, in over-confidence of its wealth and scope, it did so neglect the man with the power to make his own destiny, it would, sooner or later, fall before the attack of some more wide-awake rival.

In practically all branches of industry and commerce the inventor and discoverer are making opportunities for themselves and for the men who can divine the new tendencies they are creating. Few of even the old stable professions are safe from the revolutions of the innovator. At present the lawyer alone seems to be safely entrenched in the tradition of his calling, but his old scale of fees, it is said, has been so largely diminished in purchasing power by the cheapening of money during the last century of gold-mining and financial progress that he has had to

look to new kinds of legal business to recoup him for his losses in the older lines of practice. The doctor has been still more subject to sudden revolutions in the framework of his calling. Many new methods of diagnosing and treating diseases have been invented by the new scientific school of pathologists, and young medical students with foresight and courage have rapidly made themselves famous and wealthy by testing new treatments and then using them in the face of the sullen opposition of the traditional school. Parliament also has lately opened the doors of opportunity to a great host of young doctors, for with the introduction of the panel system of State medical service in connection with the National Health Insurance Act there have been numerous sudden openings for struggling young medical men which have probably much reduced the long waiting period they might have had to endure before they were able to get a good living by means of their dearly bought knowledge of disease.

In the meantime, the material resources of mankind are being amazingly developed by inventors and organisers and improvers. Even the social machine is being improved, or at least altered, in many ways, both by direct acts of legislation and by subtle but profound and far-reaching changes in the ideas and feelings and customs of the leading races of civilisation.

The entire conditions of the feudal system have worn out, and there is now no class, no barrier, to keep a man of ability from rising to whatever social height his native powers entitle him to claim. We have dukes now with humble ancestors, and practically all our nobility has been formed from a multitude of men drawn from traders and manufacturers who, after winning wealth, have devoted themselves to politics. Our society is in the form of a pyramid, the top of which is continually wearing away owing to the sterilising effect of luxury, while ascending and descending social movements carry the successful men of every class from the broad base of the pyramid to the perilous apex.

This gradual revolution in the social situation has been suddenly and largely accelerated by the extraordinary development of the materials and machinery of industry, with the result that the South of England has lost much of its ancient influence, and become subject to the power of the Midland and Northern provinces, which draw their strength from their vast mineral resources.

In spite of the unparalleled population of London, this Southern city does not offer the best field of opportunities in our busy little island. It affords, no doubt, a fairly comfortable means of livelihood for an immense concourse of various kinds of clerks. Owing, moreover, to the extraordinary numbers of population of this great forwarding port and railway centre, it allows scope for many small trades and industries. But the great work of the country is carried out around the Midland and Northern coalfields, and it is there that a man who feels able to make his own way will often find the largest field for his activities. From the social point of view, the South of England is a pleasant and exhilarating place in which to live; art, literature, journalism, and science are cultivated with zest in and around the capital, and it is fairly easy for men and women interested in the things of the mind to discover congenial company and develop their own talents under the stimulus of friendly intercourse with persons of a similar bent of nature. But in all other respects the creative centres of industry in our country offer a larger field of ambition to the man who aims at a successful career.

This is only natural. As a rule, where the greatest amount of work is being done there is the largest number of openings for men of ability. Sometimes, of course, a man can carve out a career for himself in a small, quiet place where there is little competition and little movement. The general stagnation is here an advantage to him, if he arrives with some novelty of growing importance which is bound to come into large use. The development of the motor industry, for example, has enabled many men of a mechanical turn of mind to build up profitable businesses in sleepy old market-towns where their services were likely to be required.

But to succeed in a large way a man must usually enter one of the great industrial centres or one of the big marts of commerce. If he is an inventor of genius there is no need to advise him what to do, for the inventor is the supreme example of the man who does not wait for his opportunity, but makes it. He is the overruling, incalculable force in the

progress of our industrial civilisation. He is the man of power, and statesmen, reformers, and merchants must wait upon his creative work or fail from ignorance of his achievements.

Next in power to the inventor as a maker of opportunities comes the discoverer. He is the man who sees that things have changed since the last organisation of methods, and he opens up new avenues of enterprise in between the overcrowded fields of settled activities, where the contest for success has grown so keen that the prize is scarcely worth the struggle. The discoverer turns to his new opening, and at times, with very little capital to start on, he quickly grows into a merchant prince or an industrial leader. Sometimes he displays a kind of inventiveness in building up a new kind of business organisation; sometimes he introduces some novelty into the market-places of the world, but as a rule he is more often the associate of an inventor than an inventor himself. His master-faculty is his intellectual vision. If a new thing is brought to him, he discerns its practical value and uses it as an engine to open his road of success through the world. In other directions, he makes new markets for improvements, and works out better methods of doing ordinary work. On the whole, men of this type are usually more prosperous than the original inventors; they aim directly at money-making and are generally alert, shrewd men of business with a larger horizon of mind than the ordinary man of affairs.

In addition to the big inventors and the big discoverers, there is a more numerous but less important class of men who also succeed by making their own opportunities. This third group may be termed the improvers of the machinery of industry and commerce. Their work requires just an ordinary good intelligence, combined with vigorous concentration of mind and with sound practical judgment. The average good worker in any field where brains are of value has as many natural advantages as the successful men of this sort. Their chief master-quality is their power of steadying their intellect and bringing all its power to bear upon the task they have set themselves. By concentrating just an ordinary strength of mind and using it in one direction, they rise above the multitude and make some opportunity for themselves by means of which they succeed. Very often the improvement they carry out is apparently a small thing in itself, but it is by a large and constant succession of little improvements that the general work of civilised countries is speeded up and lightened.

It is the host of small improvers that maps out the new territory and settles largely upon it, either in small independent settlements or as parts of the animating forces of some wealthy company. There is always ample room for the man who can better anything, either in a small or large way. The employee who can do his job well may gradually rise to a position of authority, by steadiness of character and the power of shouldering responsibilities. He stands for the old type of the man who waits for his opportunity. But if he wants to tread the path of success before grey hairs begin to appear on his wise and patient head, he must act more vigorously in this age of change and ferment and invention, and endeavour to make the opening he wants, instead of attending for it to occur.

From twenty-five to thirty-five is the period in a man's life in which he is best able to become the master of his fate. He should then have won the larger part of the knowledge and experience necessary in his career, while the active powers of his mind should be almost as strong as they were in youth, but better directed and more finely trained. Above all, the fund of high animal spirit which nature gives to the young to compensate them for their lack of wisdom should still be partly available in a young man to enable him to strike out a little for himself.

A good many men, in this critical period of their lives, lack the moral courage needed to make an opportunity for themselves. Others are too lazy, or too fond of the lighter pleasures of life, to bend themselves to the effort and concentrate their intelligence on the task of opening a little avenue to a successful position in the field of work in which they are labouring. Sometimes a man with the power of insight can see in a flash, without any preparatory toil, the chance of making an opportunity, but with most men this new start in life is only to be earned by continual striving and an alert, invincible spirit.

EDWARD WRIGHT

Build, Climate, Products, Towns, and Features of Interest of Italy. Physical Characteristics and Towns of the Iberian Peninsula.

ITALY, SPAIN, & PORTUGAL

ITALY

FROM the summit of any lofty Alpine peak south of the Rhone Valley—Monta Rosa, for example—a wonderful view is seen to the south. Vast and blue extend the plains of Piedmont and Lombardy, rich lands built up in the course of untold ages at the southern base of the Alps, and formed of the sediment carried down by the rivers descending from their snow-fields and glaciers to the Po, which, on a clear day, may be made out like a silver thread in the blue distance. The valleys opening to this plain are even more beautiful than those opening north, and the lakes which fill many of their lower ends—Maggiore, Lugano, Como, Garda, and smaller ones—have an indescribable charm of southern loveliness.

West of the Adige, all the Alpine streams descend to the Po, which flows almost due east to the shallow Adriatic, into which its delta is steadily pushing. Its tributaries on the southern bank come from the Apennines. These mountains, which form the backbone of Italy, spring from the Maritime Alps, skirt the shore of Liguria, and broaden out across the centre of the boot-shaped peninsula, leaving narrow lowlands along the sea on either side. The island of Sicily, separated from Calabria by the Strait of Messina, is structurally a continuation of the Italian peninsula. The mountainous islands of Corsica (French) and Sardinia, separated by the Strait of Bonifacio, rise out of deep seas to the west.

Climate and Products. The climate of Italy (110,500 sq. miles) is everywhere genial, and Sicily enjoys something not unlike perpetual summer. The severest winters occur in the plains north of the Apennines, but even there frost never lasts long. The summers are everywhere hot. Round the northern plains the rainfall is about 40 in. a year, and fairly uniform at all seasons. Further south it diminishes considerably, and occurs chiefly in winter. Evergreens replace deciduous trees, and the cypress, stone-pine, and evergreen oak give a wholly new character to the landscape. The characteristic Italian tree is the olive, which is grown, along with vine and mulberry, in the valleys opening to the plain of the Po, but not on the plain itself, owing to the severity of the winter. In summer this plain is hot enough for cotton and rice to be grown. The vine is cultivated everywhere. Maize is a common cereal, and a special hard wheat, used for macaroni, is grown in the south in Apulia. Agriculture is the principal occupation, but manufactures—silk and other textiles, engineering, and electrical works—are rapidly becoming of almost equal importance in the northern plain, which is the most prosperous and progressive part of Italy.

Northern Italy. The traveller enters Italy by the Mont Cenis route, which brings him to Turin, with its streets like the squares of a chessboard and its fine view of the neighbouring Alps, or by the Simplon or St. Gotthard route, which bring him to Milan, with its brown roofs, many bell-towers, and immense cathedral of white marble. Milan is the busiest town of Italy, silk being the most important of its many manufactures. From Milan we may go east by Verona, at the end of the Brenner route, and the old university city of Padua, to Venice, a city of lagoons and islands, with the magnificent cathedral of St. Mark, and, instead of streets, canals flowing between lines of palaces. Or, instead, we may go south, cross the Po at Piacenza, and pass by the famous old towns of Parma and Modena to the picturesque university city of Bologna, built at the base of the Apennines, and commanding the route across them into Tuscany. In either case we traverse a vast fertile plain, enclosed between the Alps and Apennines, crossed by a network of irrigation canals, and green with rich crops of cereals and fruits of many kinds.

Liguria and Tuscany. These provinces lie west of the Apennines. Liguria is favoured both in scenery and climate. The mountains which shut it in on all sides except the south keep off all cold winds, and its rocky shores are a dream of sunlit beauty Genoa, often called the "Queen of the Mediterranean," is a city of palaces, built round a magnificent bay backed by mountains Its commerce is enormous. Further south is Spezzia, the Italian naval station.

Tuscany slopes from the crest of the Apennines to the blue waters of the Mediterranean. Its largest river is the Arno, on which is Florence, a city no less famous for art treasures than for natural beauty, built a little below the point where the Arno leaves the Apennines. Near the mouth of the Arno is Pisa, with a grand cathedral and the famous leaning tower, once a prosperous port, but long superseded by Leghorn (Livorno) to the south. North of Pisa is Lucca, famous for oil. All Tuscany is hilly, and many of the towns—small, but often rich in masterpieces of architecture and painting—are built on the crest of steep hills above terraces of vineyards and olive yards, which yield the famous Tuscan wine and oil. Such a city is Siena, with a magnificent cathedral and art galleries.

The Tiber Basin. Similar in character, but less fertile, is Umbria, the basin of the Upper

THE KINGDOM OF ITALY

Tiber. The most famous cities are the hill towns of Perugia and Assisi, both rich in art treasures. The Lower Tiber opens to the wide plain of the Roman Campagna, once richly cultivated and densely peopled, but now covered with ruins, and inhabited only by scattered shepherds.

The Eternal City. Rome, world famous for 2,500 years, is built on several low hills rising out of the level Campagna, which, except on the seaward side, is shut in by wooded mountains. To the stranger entering it by rail it looks a modern city, but his first drive overwhelms him with monuments of Pagan splendour—the Forum, with its ruined temples; the great amphitheatre of the Coliseum, triumphal arches and columns, pillars of heathen temples built into Christian churches, the long avenue of Roman tombs lining the Appian Way, and the great ruined aqueduct stretching across the

Campagna. Innumerable magnificent churches and palaces and the immense cathedral of St. Peter's tell of the splendour of Papal Rome. In every sense it deserves the name of the Eternal City.

The Campagna of Naples. This is separated from the Roman Campagna by a tract of marshes, which are rendered uninhabitable by malaria, the scourge of Italy. Naples is built on a magnificent bay near the base of Vesuvius, an active volcano whose eruptions are often on a most disastrous scale. The surrounding plain is one of the most fertile parts of Italy. The coast is famous for its beauty, especially about Amalfi and Salerno.

On the opposite side of the Apennines are the thinly-peopled mountain lands of the Marches and the Abruzzi and the fertile lowlands of Apulia, with many good harbours, including Brindisi, the terminus of the overland route to the East.

Calabria, the toe of the Italian boot, is a thinly-peopled mountain region, with picturesque towns on the coast.

The Italian Islands. Sicily, south of Calabria, is the garden of Italy Agriculture is backward, but the fine volcanic soil is extraordinarily fertile. Cereals and fruits, especially orange and lemon, come to perfection, and in old times Sicily was the granary of the world. In the north-east is the active volcano Etna, over 10,000 feet high. Sulphur is abundant, and exported in large quantities. The chief towns, all on the coast, are Messina, on the strait; Catania, at the base of Etna; and Palermo, on the north coast.

North of Sicily are the volcanic Lipari islands, one of which, Stromboli, is often called the Lighthouse of the Mediterranean. South of Sicily are the British islands of Malta, with the fortified naval station of Valetta, and Gozo. Early vegetables are grown.

Sardinia, the only other important island, is mountainous and thinly peopled Agriculture is backward, but the soil is fertile. The mining of iron and other ores is carried on, and also in the small island of Elba, off the coast of Tuscany.

SPAIN AND PORTUGAL

Iberia. This name is given to the westernmost of the Mediterranean peninsulas, which is divided politically into the kingdom of Spain (192,000 sq. miles) and the Republic of Portugal (34,500 sq. miles). The only land frontier of Iberia is in the north-east, where the Pyrenees form the frontier of France for over 250 miles. On the north, west, and south-west it is washed by the Atlantic, and on the east and south-east by the Mediterranean, the two being connected by the narrow Strait of Gibraltar, where the fortified rock of Gibraltar guards for Britain the road to India.

Mountains and Rivers. Next to Switzerland, Iberia is the loftiest region in Europe, only a small part of the peninsula being less than 1,500 ft. above the sea. The Pyrenees are continued in the east to the south-west by the mountains of Catalonia, and in the west by the Cantabrian Mountains, rich in iron and other minerals, and rising steeply above the Bay of Biscay. From the western and eastern ends respectively of the Cantabrian Mountains come two important rivers—the Minho, flowing south-west to the Atlantic, and forming part of the boundary between Spain and Portugal, and the Ebro, flowing south-east to the Mediterranean across the large lowland of Aragon. West of the Ebro rises the Meseta, an immense lofty plateau, with a general elevation of over 2,000 ft., forming the core of the peninsula. It is highest in the east, and the rivers which flow to the Mediterranean are consequently short and rapid. The longer rivers—the Douro, Tagus, and Guadiana—follow the westerly slope of the Meseta to the Atlantic, flowing in deep gorges sunk below the level of the surrounding country. They are consequently difficult to cross, and as they are too swift and shallow to be navigable, they are useless as a means of communication. Jagged lines of heights called sierras (Sp. *sierra*, saw), rising some 5,000 ft. above the Meseta, separate them from one another. South of the Guadiana the southern margin of the Meseta, called the Sierra Morena, descends steeply to the lowland of Andalusia, which is crossed by the Guadalquivir, the most important river in the peninsula. Its waters come from the Sierra Morena and the Sierra Nevada, the latter forming the south-east heights of Spain. This lowland and that of Southern Portugal, round the Lower Douro, are the most important lowlands of the peninsula. Those of the east coast are small, but highly cultivated, especially in Murcia and Valencia.

Natural Regions. Iberia consists of three well-marked regions—(1) the Pyrenees region, including the Catalonian and Cantabrian Mountains; (2) the Meseta; (3) the Andalusian region, with the lowlands of Southern Portugal and South-eastern Spain.

The Pyrenees. The Pyrenees region belongs in climate and vegetation to Central Europe. The rainfall of the Cantabrian Mountains is heavy, while the rest of Iberia is very dry. The seaward slopes are densely forested with deciduous trees. The summers are warm, but frosts are common in winter. All the plants of Central Europe can be grown, including the vine and apple, from which wine and cider are made.

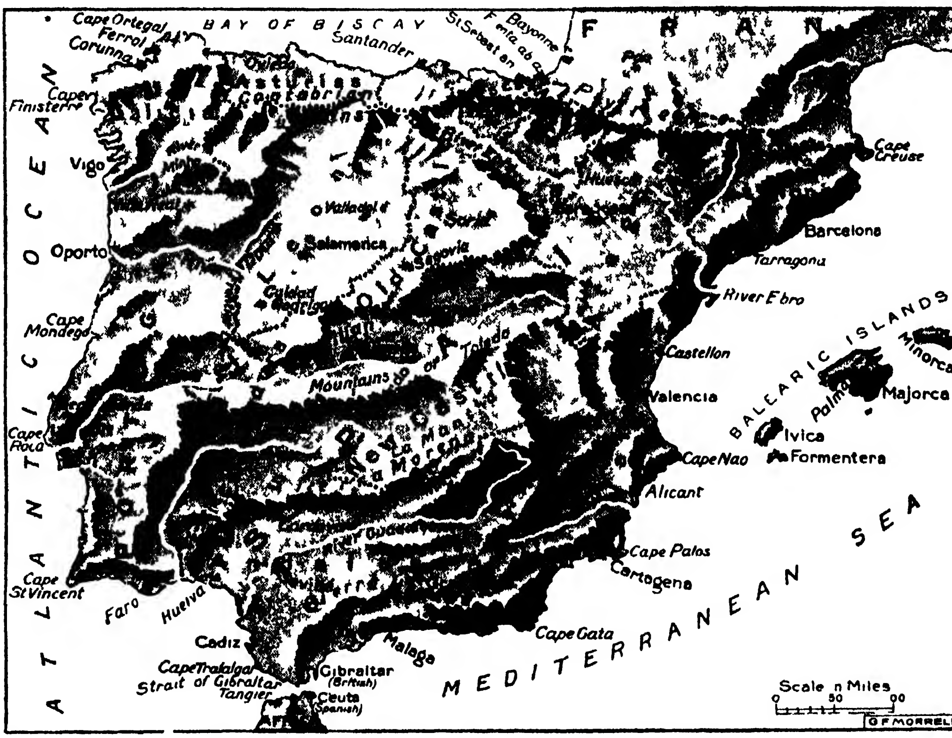
The Meseta. The Meseta is high, bleak, dry, and extreme in climate. The temperature of Madrid varies from a maximum of 104° in summer to a minimum of 14° in winter, a range of 90°. Evergreens replace deciduous trees, and in the lower west vast numbers of swine are fed in the evergreen oak forests of Estremadura. A valuable species is the cork oak, whose bark furnishes cork. The higher parts of the Meseta are too bleak for trees. Much is covered with poor grass or low evergreen aromatic plants, which supply thousands of sheep and goats with their summer pastures. Agriculture is backward, and much fertile land is unused. Water for irrigation is difficult to obtain, as the

rivers are deeply sunk in inaccessible rocky gorges. Wheat is grown where ground-water is found near the surface, but under less favourable conditions only barley, oats or rye are sufficiently hardy.

Andalusia. Andalusia and the other lowlands of the south differ from both these regions. The climate resembles that of Northern Africa, and in the better parts are grown many plants belonging to the tropics Among these are the date, which ripens at Elche in Valencia, the banana, sugar cane, sweet potato, cotton, and, in swampy districts rice The orange, fig, mulberry, and other Mediterranean fruits are almost wild Some wheat and maize and many pulses are grown The vine is very extensively cultivated, and its products are world famous

Agriculture Under Difficulties Raisins, or dried grapes and dried figs are exported in immense quantities from the ports of Valencia and Murcia, where much attention is devoted to irrigation and agriculture "The rock has to be blasted and then powdered with hammers to form soil, the slopes of all the hillsides are terraced, and every fertilising agent, even the sweepings of the streets, is utilised" Unfortunately, such a spirit of enterprise is rare in Spain The agriculture of Andalusia is backward, though its mines, largely developed by foreign capital, are prosperous It is famous, too, for its bulls and horses

Towns. Towns are more numerous on the coast than on the plateau, which is thinly peopled. On the north coasts are the ports of Bilbao and Santander, exporting iron In the Douro basin are Valladolid, in the middle of the plateau, commanding the route to Madrid across the Castilian mountains, and Oporto on the coast of Portugal, exporting port wine In the Tagus basin are Madrid, the capital in the middle of the plateau among bleak surroundings, Toledo, finely situated above the river, and long famous for fine swords, and Lisbon the capital of Portugal, built on hills at the mouth of the broad Tagus There are no towns of importance in the Guadiana basin, but a little further east is Huelva, which exports the copper of the Rio Tinto copper mines of the Sierra Morena The Guadalquivir recalls the Oriental magnificence of the Moorish conquerors of Spain Granada at the base of the Sierra Nevada, contains the Alhambra one of the most exquisitely beautiful buildings in the world Cordova has a magnificent cathedral once a mosque Seville is the most prosperous city of Andalusia, with tobacco and manufactures and a large trade All the ports of the south and south east coast—Cadiz, Malaga, Almeria Cartagena Alicante, and Valencia—trade in fruit and oil Cadiz exports the sherry of Xeres Barcelona is the chief city and port of Catalonia, the one part of Spain which is progressing industrially Its manufactures and trade are very important

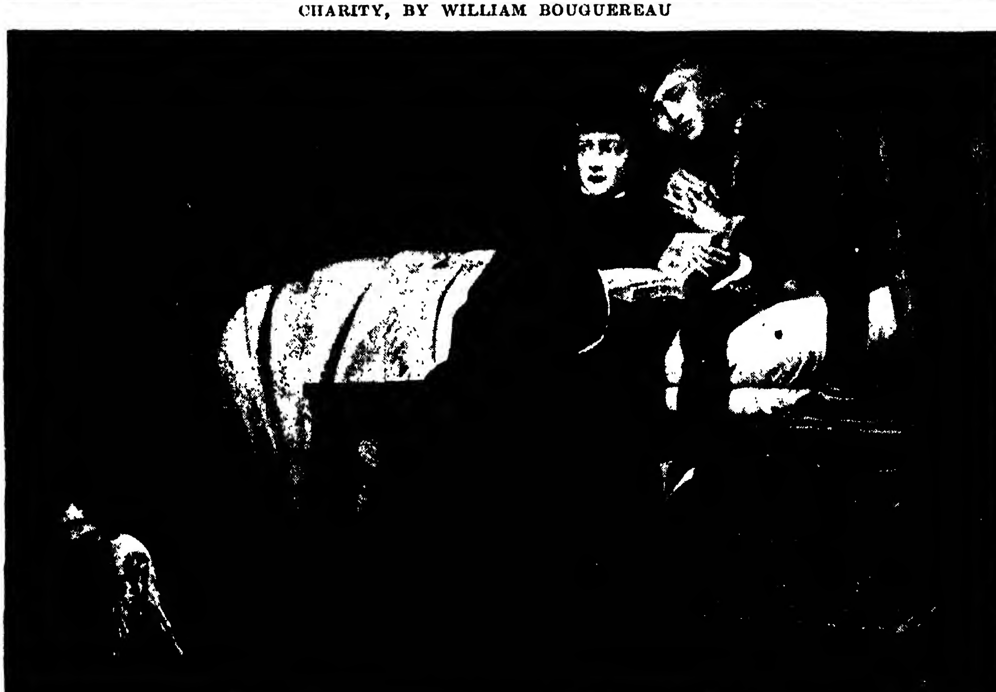


THE IBERIAN PENINSULA—SPAIN AND PORTUGAL

Off the east coast are the Balearic Islands The largest town is Palma on Majorca, the largest island.

A. J. AND F. D. HERBERTSON

CHARITY, BY WILLIAM BOUGUEREAU



THE CHILDREN OF EDWARD IV. IN THE TOWER, BY PAUL DELAROCHE

Gainsborough, Reynolds, and Romney. Landseer and Wilkie. The Pre-Raphaelites. French Impressionism. Rodin, Meunier, and Stevens.

ART IN MODERN TIMES

At a time when Italy, Flanders, Spain, Germany, and France were witnessing the rise of great national schools of painting, England had to be content with deriving her art from foreign sources. Not that there was not an abundant supply of native talent from the days of Henry VIII. to the beginning of the eighteenth century, when Hogarth (A.D. 1697-1764) appeared on the threshold of a brilliant period of artistic activity, but the leaders around whom these painters gathered, and from whom they took their style, were of foreign blood and birth. Holbein was the first of the foreign masters who worked at the English Court and determined the manner of a whole generation of portraitists, especially of miniature painters, and Van Dyck, the Court painter of Charles I., may, with good reason, be called the father of English eighteenth century portraiture.

His influence was great and lasting, though two other foreign masters stand between him and Gainsborough—the Germans, Sir Peter Lely and Sir Godfrey Kneller. Antonio Moro, Daniel Mytens, M. Mierevelt, Rigaud, Largillière, and Canaletto all worked in England, and had their followers—capable artists like Dobson, Walker, and Samuel Scott, who have left us many works of merit without adding a single new page to the history of art.

The first original word uttered by a British artist was spoken by Hogarth. Before him, painting in England had been altogether aristocratic and stately. His art was robust and healthy and democratic, almost plebeian. There is much of the English puritanical spirit in his scathing satires on the vices and weaknesses and immoralities of his contemporaries. He is, above all, a moralist—a preacher who uses his art as a weapon in the cause of virtue and righteousness. But these inartistic subjects are painted with consummate artistry. If the anecdotal painter generally fails, it is because a commentary is so often needed to make his work intelligible. Hogarth never supplies illustrations to other people's ideas, but tells his own stories with unmistakable directness in the language of paint. He conceives them as pictures, and, if one has eyes to see, one needs no explanation either of the story or of the moral to be drawn from such picture cycles as the "Mariage à la Mode," the "Rake's Progress," "The Idle Apprentice," and "The Industrious Apprentice." At the same time, Hogarth never allows his literary intention to interfere with the purely artistic consideration, never sacrifices beauty of arrangement and harmonious colour to the clearer telling of the story. The mastery of his brushwork can best be judged from a picture like the "Shrimp Girl," at the National Gallery, where the sheer beauty of paint can be enjoyed without the distraction of a moral sermon.

The second half of the eighteenth century witnessed the rise of the great school of British portraiture, of which Gainsborough, Reynolds, and Raeburn are the brilliant luminaries. Of the two first-named, Gainsborough may be said to be the representative of the aristocratic and Reynolds of the democratic tradition.

Gainsborough is, above all, the painter of the graceful elegance of contemporary society—his ladies are beautiful, distinguished, refined, his men slightly dandified; and his very technique, his deliciously cool colour-schemes, and the negligent but sure elegance of his touch, reflect the character of his sitters. Van Dyck is his real master, and his affinity with him appears clearly in such a picture as the famous "Blue Boy," which was painted in defiance of Sir Joshua's dictum that blue cannot be made the dominating colour of a successful scheme.

Reynolds, unlike Gainsborough, who had never left England or made a profound study of the old masters, had steeped himself in the art of the past, and based his designs, his style, and his colour on the Italian masters. He was for ever proclaiming his allegiance to the "grand style," and his more ambitious compositions hold more than an echo of Tintoretto and Titian, of Correggio and Michelangelo, and even of Guercino and the later Bolognese. But not on these does

his fame depend. With a curious perversity, which we find to an even greater degree in Romney, he set little store by his portraiture, which he considered mere drudgery, and pinned his faith to painting "histories" in the grand manner of the later Italian masters. With all their noble qualities of colour and design, they would today not suffice to secure Reynolds the eminent position he holds in the art of his country. This position is due to his powers as a portrait painter. And, as such, he is the antithesis of Gainsborough. He is as intellectual and searching as Gainsborough is elegant and superficial, and his sitters were not so much the society beauties of the day, but the aristocracy of intellect—men of letters, politicians, actors, philosophers, and scientists. In the place of the cool, musical colour of Gainsborough applied in loose, thin touches, he prefers a hot, sumptuous scheme carried out with firmness and energy in a thick impasto. As likenesses, his portraits are far more convincing than those of his rival. He particularly excelled in portraying the innocent charm of childhood

George Romney. George Romney, whom fashion has placed beside these two masters, scarcely deserves to be held up as their compeer. His sense of beauty and techincal skill were certainly second to none, but he fell into a mannered convention which, while searching for prettiness—and finding it—lost in character and sincerity. The vast number of portraits left by his brush might all have been painted from members of the same family. Raeburn (A.D. 1756-1823), the greatest master produced by Scotland, has, unlike Romney, met with comparative neglect, though he is now rapidly gaining the recognition which is his due as the father of the modern Scottish school, a daring colourist of rare strength and virility. As regards summary expressiveness and breadth of brushwork he is unapproached by any of his contemporaries. With broad sweeps of the brush he suggests all the subtleties of modelling and drawing. Hoppner, Opie, and Cotes must be mentioned among the masters of those halcyon days of English portraiture, while Sir Thomas Lawrence connects these days with the period of academic sloth from which English painting was only liberated by the Pre-Raphaelite revolt.

THE BURGHERS OF CALAIS—A SCULPTURE GROUP BY AUGUSTIN RODIN

Landseer and Wilkie. Only landscape painting made giant strides in this period, and Constable and Turner showed the way to the Barbizon men and the impressionists, while soapy and insipid portraiture, uninspired relating of anecdotes in paint, theatrical scenes of history, and suchlike, held the public. Even where there was real talent, as in the case of the animal painter Landseer, concessions had to be made to the demand for humorous anecdote. David Wilkie was among the great artists of that period, a real master in the handling of pigment which with

PORTRAITURE BY FOUR BRITISH MASTERS

MISS BOWLES, BY SIR JOSHUA REYNOLDS

MISS HAVERFIELD, BY THOMAS GAINSBOROUGH

WILLIAM HOGARTH, BY HIMSELF

REV. J. HONE, BY SIR HENRY RAEBURN

him retains an extraordinary richness of quality in spite of the minute precision of his detail. He was influenced chiefly by the Dutch small masters, and his skill in composing and arranging groups of figures and in massing the light and shade deserves the greatest admiration. William Blake, a mystic whose weird, fantastic imagination defied all laws of Nature, belongs to this time, but was an isolated appearance in the history of art.

LORENZO AND ISABELLA, BY SIR J. E. MILLAIS, P.R.A.
From the painting at the Walker Art Gallery, Liverpool

The Pre-Raphaelite Brotherhood. On the whole, English painting was at its lowest ebb in 1848, when a few ardent young spirits, led by D. G. Rossetti, J. E Millais, and W. Holman Hunt, resolved to renounce the artificial academic formula of the day, and to follow the example of the Italian primitives, to approach Nature in a humble, naive spirit, and to do away with theatrical posing and bituminous shadows and ready-made recipes for making pictures. The famous picture "Lux Mundi" is perhaps the best known work by W. Holman Hunt, and another excellent example is the "Lorenzo and Isabella," by Millais. Every detail, every grass blade or flower, stone or furrow, was made the object of careful study from Nature—so much so, that at times the larger truth was lost sight of in the passion for microscopic truths. As regards subject, romance and poetry were put in the place of the trivialities which then had the applause of the public.

The works of the Brotherhood aroused a storm of indignant abuse, but a powerful defender of their aims appeared in Ruskin, who threw himself heart and soul into the movement. The Brotherhood, as such, was short-lived, but the influence has been lasting, and is still to be felt in the art of to-day in spite of the growing supremacy of French ideas and technique.

Art Under "The Empire." In France, which we have left at the threshold of the Revolution, more perhaps than in any other country, the political and social conditions are reflected by the currents of artistic evolution. The lascivious art of an immoral Court was followed by the chilling classicism of a Louis David, a true child of the Revolution, who, in his reconstructions of Ancient history, glorified the self-sacrificing patriotism of the Roman Republic, and then, as Court painter to Napoleon, became the originator of the Neo-Greek "Empire" style. With Napoleon's victorious campaigns arose an important school of battle painters, of which Gros and Gérard were the leading spirits. But neither art nor literature flourished during the first Empire, and only after the Restoration the intellectual life of France began to flow again in many contending currents. The first great battle was waged between Ingres, the head of the classicist school, who based his art on the imitation of the antique and perfect draughtsmanship, and Delacroix, the leader of the Romanticists, a truly inspired artist, with a glowing sense of colour and a powerful imagination. Then came the revolt of the Barbizon men, then the struggle of the freelight painters, and finally of the impressionists, whose aims have already been set forth in the article on "Landscape Art."

Impressionism in France. But impressionism has another aspect besides that of which Claude Monet is the chief exponent. As conceived by such masters as Manet and Degas, it substitutes beauty of character for beauty of form, and turns the attention of the artists to scenes of contemporary life. Classicism and academic art in general sail in lofty regions far removed from the bustle and strife of every-day life. The impressionists maintain, and frequently prove by their works, that the meanest subject is worthy of pictorial treatment if it is seen by the eye of an artist. As the word conveys, *impressionism* is concerned with the impression of a scene, which can only be recorded in its completeness by summary suppression of all the details which cannot be grasped at a rapid glance. The academic painter loses the freshness of an impression by using his *knowledge* of the form of things to penetrate the mysteries of distance or deep shadow. The impressionist loses outline and form where they are lost in Nature, and thus attains greater verisimilitude. The academic painter, in

treating the figure, loses the sense of movement through overcarefulness in drawing. The model is turned to stone, as it were, in the act of running, or wrestling, or dancing; while the impressionist, sometimes through accentuation, which is not, strictly speaking, correct, or through the effacing of contours, often succeeds in conveying an extraordinary suggestion of movement. Thus, in the ballet scenes by Degas, the dancers seem to be actually circling and pirouetting round the stage. As an example of Manet's work a reproduction is given of "A Bull Fight"

Four Great Masters. Like the Pre-Raphaelites in England, the French impressionists had to fight a hard struggle before their views found acceptance, and there is no doubt that the extreme manifestations of impressionism frequently degenerate into absurdity and ugly caricature, and fully deserve the ridicule that has been heaped upon them. Yet it has remained one of the leading factors in modern art, not only in France but throughout Europe and America. Its influence has not always been beneficial, for the incompetent frequently sails under its flag to conceal lack of training and deficient draughtsmanship; but on the other hand, it has enriched the world with the masterpieces of a Monet, a Manet, a Degas, and a Whistler.

Nineteenth Century Art. In the rich artistic life of nineteenth century France, impressionism was only one, though the most important, phase. The academic school continued to flourish in the art of accomplished painters like Meissonier, Bouguereau, Delaroche, Fleury, and many others; the Orientalists, who found their subject-matter in the sumptuous picturesqueness of the East, are chiefly represented by Decamps, Fromentin, and Marilhat; decorative wall painting attracted masters like Puvis de Chavannes and, more recently, Besnard; Bastien-Lepage stands at the head of the freelight painters; while the most recent group, the intimists, include Le Sidaner, one of the most fascinating artists of the present time.

Rodin and Stevens. In sculpture, France took an uncontested lead during the nineteenth century. Rude (A.D. 1784-1855) was the first to return to the national tradition which the followers of Canova had forsaken for cold classicism. Barye (A.D. 1796-1875) stands unapproached as a sculptor of animals. Carpeaux, Frémiet, Dalou, and Falguière must all be reckoned among the masters of their art. They all went to Nature for their inspiration, instead of continuing the imitation of the antique that was so prevalent in the early part of the century. Rodin, finally, achieved the introduction of something like impressionism in sculpture. Of the masters of the past, Donatello is the one with whom he shows the greatest affinity, though Rodin's style is entirely original and personal. Through the accentuation and amplification of certain planes, he not only succeeds in suggesting movement, but a curious softening of the silhouettes, which makes his statues and groups appear as if they were bathed in atmosphere. Rodin, like all great reformers, met with bitter opposition, but to-day his pre-eminence in the field of sculpture is admitted by those who are most competent to judge. An example of his work is to be found on page 2010. In Belgium, Constantin Meunier has created, in stone and bronze, a mighty epos of Labour. His aims and achievements in sculpture are almost identical with Millet's in paint. The one great sculptor produced by England in the middle of last century was Alfred Stevens, whose Wellington Memorial in St. Paul's Cathedral is worthy to be placed beside the masterpieces of the sculptors of the Italian Renaissance. The last decades of the century witnessed an important advance in plastic art, and English sculptors of to-day have little to fear from comparison with their Continental contemporaries.

A BULL FIGHT, BY MANET

P. G. KONODY

The Eyeball and its Protection. The Iris and the Pupil. How Colours are Distinguished. Long and Short Sight.

THE STRUCTURE OF THE EYE

We have dealt with the main functions of the brain, and it now remains for us to consider the special senses and the faculty of speech. We begin with the eye, and the first thing we should clearly understand about it is that it does not see, and cannot see any more than a photographic camera. In the latter, the object is focussed through a lens into a dark box, at the back of which it is pictured on a sensitive plate, but the camera does not see—it is the man behind the camera who sees. He peers through the ground glass at the back, and sees the object mirrored there. Of course, it may be objected that this is necessarily so, since sight is an attribute of life, and the camera is not alive. This is true, but nevertheless the illustration is of force because it is difficult to realise that the eye by itself is exactly like the inanimate camera, alive though it be, only receiving and reflecting the images, and that it is the brain behind the eye which really sees.

The Real Centre of Sight. We have already noted that the "optic lobes," the real centres of sight by which we see, lie in the base of the brain just in front of the pons in the medulla. These lobes are directly connected, each of them with both eyes; and if one lobe be destroyed, total blindness of the opposite eye ensues, while if both are destroyed, complete blindness ensues, though all images are pictured on the two eyes, or "cameras," as perfectly as ever, and that, too, by vital and not merely chemical processes. This is seen in cases of disease destroying these lobes, which are therefore the psychic centres of sight. In exactly the same way the ear does not hear, nor the tongue taste, nor the nose smell.

The Eyeball and its Protection. Each eyeball [85] is a hollow, flattened sphere, about 1¾ in. in diameter, lying in a pyramidal bony cavity known as the orbit. This is filled with fat, in which the eyeball rests as on a cushion, and revolves freely in a capsule without the least friction. This orbit protects the eyeball from any ordinary injury in front, where it is very strong; but behind the eye its walls are very thin, so that the point of an umbrella thrust into the socket might easily enter the brain, and yet an iron hat-peg nearly 3 in. long has been extracted from the orbit, where it had lain for some days without causing much inconvenience! The eyeball is still further protected by the *two eyelids*, the upper of which, at any approach of danger, closes down involuntarily in front of the eye. Above and on the outer side lies the *lachrymal gland* [86], and every time the eye winks a tear is squeezed out of it and sweeps across the eye, washing all impurities away, and leaves the eye by a little duct leading into the nose. This takes place about five times a minute. Only when the tears are rapidly excreted under the influence of emotion do they roll over the lower lid and we are said to "cry." Tears are not secreted before six months—infants, therefore, do not really "cry."

Six muscles are attached to the sides of the eyeball by small white tendons, so as to pull it in every direction. One of these tendons which rolls the eye upwards runs through a perfect little pulley in the top of the orbit [87].

It is of the utmost importance that both eyes should move together, and this has been secured by a similar nerve supply to both eyes—an arrangement that is generally, but, as we shall see, not always, successful. When it fails, we squint.

Why Both Eyes See the Same Object. The two eyes are, of course, the sole cause of *stereoscopic vision*, by which two pictures from slightly different points of view are combined into one, thus giving the sense of space or solidity—in short, truly picturing the world of three dimensions in which we live. Had we but one eye, we should see everything in the same plane in two dimensions only, and find it very difficult to understand solidity.

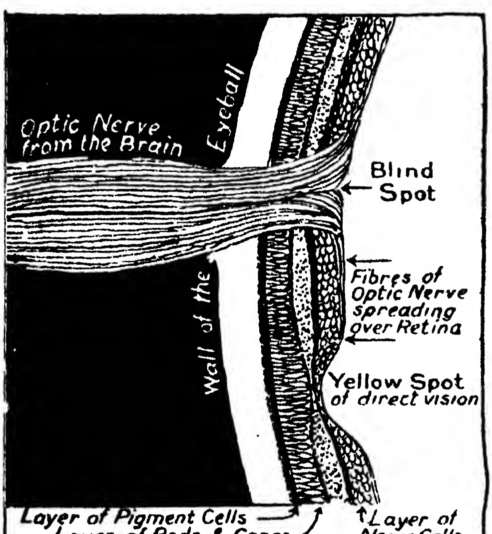
In front of the eyeball is inserted a circular, transparent membrane called the *cornea* [85], through which all light enters the interior. It is apparently "let into" the eyeball, much as a watch-glass is let into the face of a watch. It is really, with the rest of the outer coat of the eyeball—called the sclerotic—comprised of very tough fibrous tissue. In the cornea alone the cells are perfectly transparent, and are arranged in perfectly parallel rows, and there are no blood-vessels.

Mechanism of the Eyeball. It is difficult, as we look at this transparent, glass-like structure, to believe it is composed of about 100 layers of living cells. The surface consists of a false skin, like the epidermis of the body, with the same active life going on every hour. The substance beneath is a mass of transparent, flat, fibrous bands, with irregular spaces between them. These spaces are filled with white corpuscles from the blood—a matter of great interest, because here their movements can be most closely watched during life. If a little aniline dye be injected into the leg, after a time some part of the cornea may be tinged with the colour through white corpuscles which have absorbed it into their bodies having made their way to the eye.

It is evident that on the perfect transparency of the cornea all sight depends, for at the present

time, when once the cornea has become opaque, no means is known of restoring the sight. The eyelids are lined with a delicate skin called the conjunctiva, which is continued all over the eyeball, and whose anterior layers form the epidermis of the cornea.

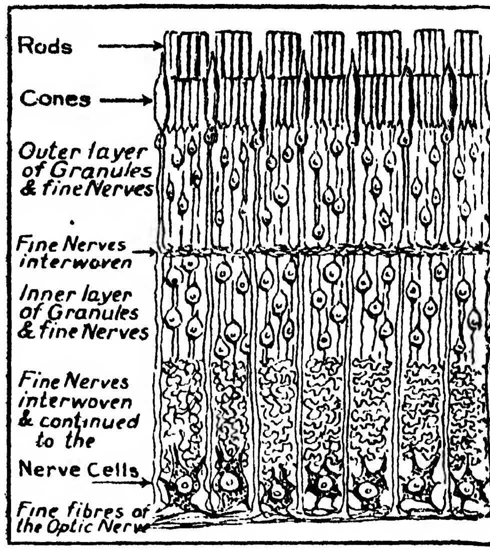
The Iris and the Pupil. On the inner side of the cornea is a *small chamber*—like the space between the watch-glass and the watch—filled with a *clear watery fluid*, called the aqueous humour. The chamber is bounded behind by the iris, a coloured muscle with a contractile circular aperture or diaphragm, through which the image to be seen enters the eyeball. The two irides are not always of the same colour, and brown spots are frequently seen upon them. In albinos they are pink, because, having no colour, the blood is seen through them; and as too much light thus enters the eye, these individuals see best in the dusk. The pupil, or black hole in the middle of the eye, varies in size according to the amount of light and distance of the object. It cuts off all superfluous light, so that the image is defined sharply and clearly. The muscles of the *iris* can contract the aperture, or *pupil*, to a pinhole, or expand it to one-third of an inch. The pupil only looks black because the interior of the eyeball is dark. Its average size is $\frac{1}{8}$ in., and the centres of the pupils should be $2\frac{1}{3}$ in. apart. In a dark room, or when looking at objects a long way off, the pupil is expanded, and it is contracted in bright light or when looking at near objects. This far-away look, from gazing at distant objects, by expanding the pupils, increases the beauty and "depth" of the eye, and is sometimes



82. A SECTION OF THE EYEBALL THROUGH THE BLIND SPOT AND THE OPTIC NERVE

cultivated artificially, and often depicted in sketches of female heads. Certain drugs, such as atropine, enlarge the pupil, also fear, weakness, and alcohol. Other drugs, such as the Calabar bean and opium, contract the pupil. In men, the muscle acts involuntarily, but animals that prey by night, as cats and owls, can, it is said, use it voluntarily.

The Focus of the Eye. Just behind the "iris," or coloured curtain of the eye, lies the



83. THE NERVE LAYERS AND RODS AND CONES THAT FORM THE RETINA

crystalline lens [85], by which all images are brought to a focus on the back of the eye. This lens is *bi-convex*, and about half an inch in diameter, and its effect can be seen by focussing any view or object on a white sheet of paper, with a similar lens. The distance of the lens from the paper requisite to produce a clear focus on the paper is determined by the distance of the object, the whole variation being, however, very slight, the length of the focal distance between an object 20 ft. off and one 4 in. being only $\frac{1}{10}$ in. In the camera, where the image of the sitter has to pass through the lens on to the ground glass or sensitive plate at the back, the length of the focus is adjusted by moving the lens backwards or forwards with a screw until the focal length is arrived at, and a clear, sharp, reversed image of the object is obtained. In the eye the lens is fixed, and the sensitive screen that receives every image is also fixed, about $\frac{3}{4}$ in. behind it.

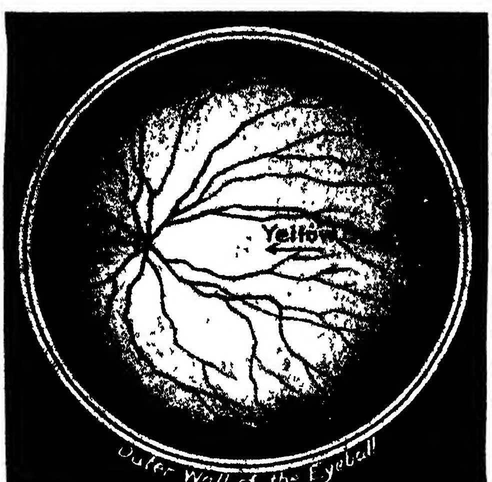
Near and Distant Objects. To understand the focussing of the eye, one or two points must now be made clear. All vision is divided into "far" and "near." All objects over 20 ft. are "far," or "distant," all others are "near." In the normal eye, the rays of light from each object over 20 ft. distant, being parallel, are naturally focussed on the eye by the lens, the only adjustment needed being, as we have shown, an enlargement of the pupil to admit more light. Objects under 20 ft. require what is called accommodation, as rays of light from these are divergent. This is an operation performed unconsciously and exactly, according

to the distance of the objective from the eye. Whether an object is 30 ft. away or 30,000,000 miles, no change in the eye is needed to see it, but a great change in the eye is needed to see an object at 10 ft. and another at 2 ft. The change required is threefold: the pupil is contracted and the two eyeballs converge—a slight inward squint—according to the nearness of the object, and lastly the lens becomes increasingly convex according to the same law. This is necessitated in the eye when the focal distance is fixed, but is not required in the camera when the focal distance can be altered instead. The more convex the lens, the shorter the focal distance, and the lens is therefore automatically altered according to the distance from the eye of any object under 20 ft.

The lens is of almost perfect elasticity, and a thin membrane stretched across the front of it keeps the anterior surface flatter than the posterior, and a special set of muscles instinctively relaxes this membrane to let the front of the lens become more convex as required. Accommodation, or adjustment of vision, for objects under 20 ft. is therefore a threefold muscular action—namely, contraction of pupils, convergence of eyeballs, and convexity of lens.

Behind the lens is the interior of the eyeball, filled with a *delicate crystalline jelly*, through which the light passes to the back. All the light comes through the aperture in the iris, which, whatever colour it may be on the front, is itself black on the inside, to prevent any rays penetrating into the eye, except by the pupil.

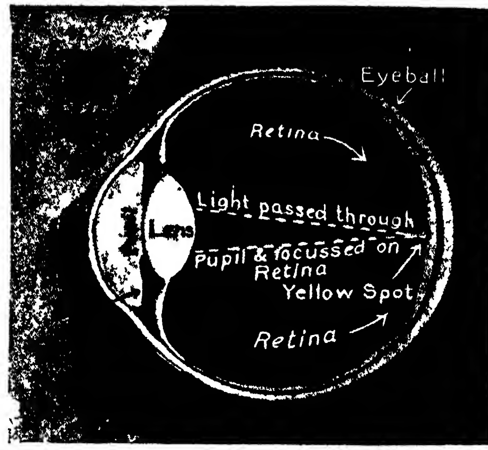
The Nerve to the Brain. The nerve that passes from the brain into the eyeball to the centre of sight is like a stalk to the eye, and is



84 THE YELLOW AND BLIND SPOTS

as thick as a small slate-pencil [87]. It does not enter the eye exactly at the back, but $\frac{1}{10}$ in. to the inner or nasal side, and then spreads out into a thin film called the *retina*, $\frac{1}{80}$ in. thick, all over the inside of the eyeball, excepting the anterior third, where no image nor light can ever come. It does not lie immediately in contact with the white "sclerotic" coat of the eyeball itself, for between the two is a layer of cells called the *choroid*, having the appearance of *black velvet*, so full are they of black pigment, which forms an admirable background for the transparent nerve film that lies on it, while it allows no ray of light to pass through.

This nerve film [82 and 83], thin as it looks, consists of some dozen most complicated layers of



85. DIAGRAM OF THE EYEBALL

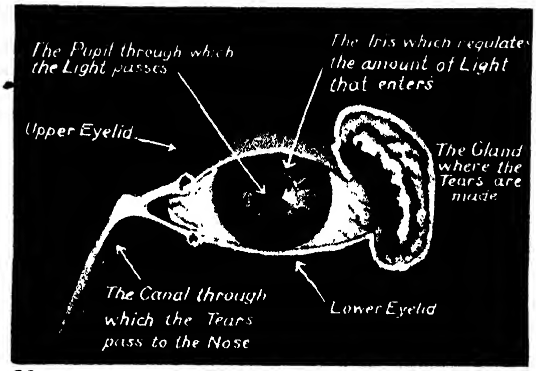
cells of various kinds, the innermost, next the choroid, being a layer of so-called "*rods and cones.*" The rods are filled with a delicate fluid called the visual purple, which is bleached as the light falls on it. They are supposed to give the picture looked at in black and white, while the cones are supposed to be connected with the colour sense, certain of them responding to the red rays, others to the blue, and others to the green or yellow. The retina itself is quite transparent during life, but cloudy and pink after death. Opposite the centre of the lens, at the very spot where all objects are focussed that are directly looked at, there is an elevation called the *macula lutea*, or yellow spot [84]. The optic nerve enters $\frac{1}{10}$ in. to the inner side of this spot. In this spot, all the layers disappear except the cones, and sensitiveness decreases with the distances from it. Thus, 5° away, the sight is only $\frac{1}{4}$ as acute; at 10°, $\frac{1}{15}$; at 20°, $\frac{1}{40}$; at 30°, $\frac{1}{70}$; and at 40°, only $\frac{1}{200}$. Beyond this, vision is imperfect. Every nerve fibre that enters the eyeball by the optic nerve is connected with about seven cones and pigment cells, and 100 rods.

On the rods and cones that lie innermost against the black choroid coat every object from the external world is thus temporarily photographed.

We can "see" many things at once, but we can only "look" at one object at a time—that is, focus it on the yellow spot.

The Blind Spot. As we have seen, *the optic nerve itself cannot receive any image*; and as there can be no retina where it enters the eyeball, so part of every image we see is lost, as if a black hole were punched out of it [82 and 84];

only we never notice this, any more than the fact that everything we see is upside down, because we have learned instinctively not to notice the blank spot, and also to reverse the visual image in the mind. But that the "blind spot" exists is proved by closing the left eye, looking steadily at this cross, and slowly raising the head up to a certain point; the black dot will be seen as well while you still gaze at the cross, but at a certain height it will suddenly disappear. At this height, while the cross is impressed on the yellow spot, the black dot is just on the optic nerve, and hence is not seen, proving the nerve of sight itself to be blind, and only able to receive impressions of objects through the retina.



86. THE EYE, SHOWING THE GLANDS AND ...S THAT CLEANSE THE EYEBALL

The eye gazing at any bright object soon gets exhausted, for the object is not merely mirrored, but positively photographed, as we have shown, upon it. If a rabbit be killed in front of a window in a bright light, and its retina examined, the bars of the window can be seen bleached upon it. Hence, for a time after coming into the house on a dazzling day we are quite blind.

And here let us once more compare the eye with the camera. A photographic artist, standing by a sensitive camera, looks at the object with his eye, and we may observe the simultaneous process going on in the two. At the same instant that he takes the cap off the camera he may open his own eye wide, and thus takes off the cap, or eyelid. The light reflected from the object now streams in at the cornea in the eye and at the opening in the camera. Passing backward in both, the first thing met with in each is the bi-convex lens. This serves to gather up the diverging lines of light from objects under 20 ft., or parallel rays from objects over, and causes them to converge to a focus as they pass in to the sensitive plate in the camera, or the retina of the eye. On each, they at once bleach the object reversed. Here, in the camera, the process ends; in the eyes, the image is at once conveyed along the optic nerve to the centre in the brain, which "sees" it. The eye has one great advantage over a camera, owing to the fact that it has a *curved* retina equidistant in every part from the lens. The camera has a *flat plate,* and can only therefore perfectly focus a very small part at the same time.

How the Eye Sees Colours. Light itself consists in the movement of *luminous waves of ether* travelling at a speed of 186,200 miles a second, *red waves* being the *longest*, and *violet* the *shortest*, *green* occupying a *middle place*. This perhaps accounts for the rest that green gives to the eye, for being of a middle tone its vibrations are not so fatiguing as those that are very rapid or very slow. The variations in light-waves are, however, much more limited than sound-waves. Each colour is caused by waves of light of a definite length, and certain cones seem able to take up only the red rays, others the green or yellow, others the blue or violet. The solution of the puzzle on our walls of "Pears' Soap" is thus quite obvious. We stare at the great red letters until all our red cones are exhausted, and we cannot see with them; then, if we turn our eyes away, though the whole image of the "Pears'" is fixed for a time on the retina, the red cones being exhausted, we only have the blue and yellow left, and hence see it as green. Of course, if the red were not exhausted, and we turned away, we should not see it in any colour at all, for all colours together make white light.

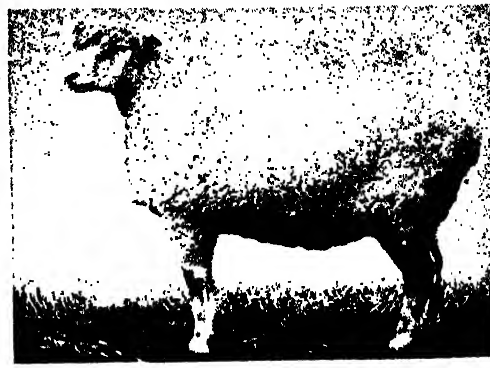
Colour-Blindness. Colour-blindness is not at all uncommon, and in some cases is most dangerous, particularly in railway employees, for red blindness, which is the most common in engine drivers and others, might lead to fatal consequences. Prolonged smoking of strong tobacco often causes such red-blindness, so that no difference can be seen between a red rose and its leaf. Colour-sight, like all else in the body, increases by practice, the cones being living cells. Acuteness of vision is dependent not only on a perfect eye-camera, but is partly psychical and due to long practice. Four thousand years ago the Arabs named a small star in the tail of the Great Bear, now just visible, "Saidak," or the Tester (of sight), and today their vision is wonderfully keen.

87. THE MUSCLES AND NERVES THAT SERVE THE EYES

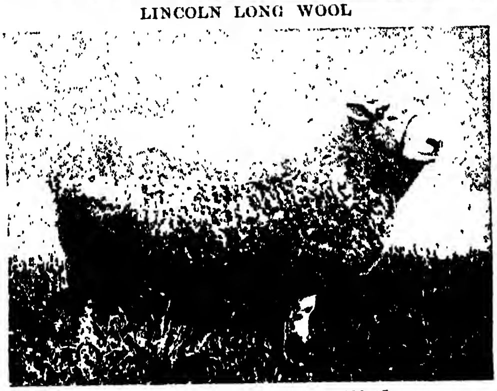
A. T. SCHOFIELD

SOME TYPICAL BREEDS OF BRITISH SHEEP

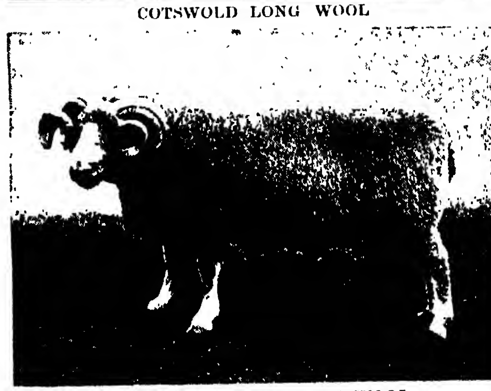
LINCOLN LONG WOOL



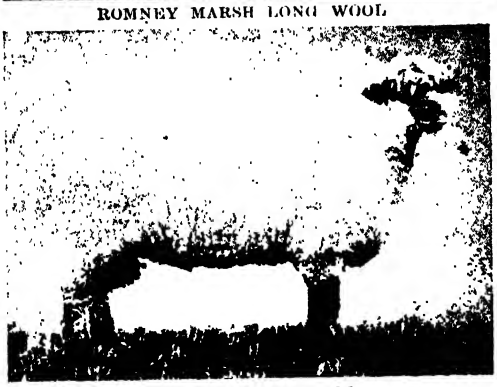
COTSWOLD LONG WOOL



ROMNEY MARSH LONG WOOL



DORSET HORNED SHORT WOOL



OXFORD SHORT WOOL

SUFFOLK SHORT WOOL

SCOTCH BLACKFACE MOUNTAIN

WELSH MOUNTAIN

 The photographs of the Oxford and Suffolk Breeds are by courtesy of Messrs. Chivers & Son, Histon

British Long Wools, Short Wools, and Mountain Breeds. General Management. Dipping. The Profit from Wool.

SHEEP AND SHEEP BREEDING

THE sheep has always played an important part in the history of agriculture. Although it has not served as a beast of burden like the ox, still it supplies practically everything in the form of clothing and food which man requires when in a primitive state. That it was associated with man in the pastoral stage we gather from early records, clearly showing its remarkable adaptability to stand various changes of climate, and to thrive under adverse conditions. Little seems to be known of the early ancestors of the present British breeds, or when sheep first appeared in the British Isles. It is known, however, that British wool was held in high esteem, and a woollen manufactory flourished in England shortly after the advent of the Romans.

The Value of Sheep. For many years sheep were cultivated almost entirely for their wool, and it was not till later, when the population of the United Kingdom increased, that the value of the carcase was recognised, and the fleece began to be sacrificed for the better production of mutton. And it was only during the nineteenth century that, owing to the enhanced skill of breeders, the highest method of bringing wool and flesh to perfection was achieved. The quality of the wool, however, has in some respects deteriorated, and for the manufacture of the best classes of goods recourse is now had to merinos.

Another characteristic of the sheep which is of great service to the farmer is its power of improving and restoring fertility to land upon which it is fed. On sandy soils and poor, light land the value of sheep for this purpose cannot be over-estimated. The old Spanish proverb "The golden foot of the sheep" refers to this fact. The treading of the small feet in consolidating light soils is also an advantage for the growth of the succeeding crops.

The breeds of sheep in the British Isles are best classified according to their fleece into long wools, short wools, and mountain breeds. We first review the LONG WOOLS.

Leicester. Owing to its history, and to the fact that it has been made use of to improve several of the other breeds, this breed may be looked on as the most important race of English sheep. It was the breed which in 1755 Robert Bakewell, of Dishley, in Leicestershire, started to improve by his methods of in-breeding and selection. The sheep he began with was a large-framed, slow-growing, coarse animal, with a heavy fleece of somewhat indifferent quality. This he converted by his special methods into a smaller, more symmetrical, and finer-boned sheep, with better fattening qualities. His principal aims were improvement of form and quality of flesh, combined with early maturity; and he treated the question of the fleece as a matter of quite secondary importance. The improved characters and more rapid feeding qualities of Bakewell's flock after a time attracted the notice of his neighbours, and shortly afterwards a demand sprang up for the use of rams of his breeding for improving the sheep-stock in his own and other districts.

The modern type of Leicester shows the characteristics thus developed in a marked degree, and in consequence it has for many years been sought after by Continental and other breeders for purposes of crossing, although some other breeds, which owe their improvement to Leicester blood, like the Lincoln, have achieved a much greater popularity, owing to the length and quality of their wool.

Characteristics of the Leicester. The following are the special points of the breed: The head is small and fine, and slightly woolled on top; the face is white, with a slightly blue tinge, and the ears thin and long. The body is square in frame, with the fore quarters specially well developed; the hind quarters are, as a rule, not so full as they should be, and often form a weak point in the breed.

The bone should be fine, and, together with the fibre of the fleece, should show evidences of quality. There should be a marked tendency to fatten early, but this, unfortunately, is often combined with an undue laying on of fat, which deteriorates the quality of the mutton.

Bakewell's success in the improvement of the breed may be attributed to (1) extraordinary powers in judgment of form and quality; (2) his endeavours to obtain the best stock from all sources; (3) his system of breeding from closely related animals; and (4) the elimination of all animals not conforming to the type he was aiming at producing.

Border Leicester. This is a larger animal, stronger in the bone and more vigorous than the English type. There is little doubt that it originated from Bakewell's Leicester by crossing with North country ewes. The head is long, and the face is covered with short, white hair, which extends well back behind the ears; the legs are also clean and white. The body is well set up, but presents a somewhat light appearance, owing to the length of leg. The wool, which is in little locks, is lustrous and soft, although the fleece is sometimes too open. The breed is particularly found in Northumberland and on the Scottish border.

Cotswold. The Cotswold is a very ancient breed, whose home for generations has been the Cotswold Hills of Gloucestershire. It is specially

noted for its style and graceful carriage, and the large tuft of wool on the forehead, which hangs down almost to the nostrils. The ewes, however, gradually lose this tuft with age.

The head is well carried on an arched neck, and the face is either white or slightly mixed with grey, with legs to match. The body is long, level, and wide, with a broad, straight back well covered with firm flesh. The fleece should be composed of long, lustrous wool, and have a well-defined lock, showing a wavy curl. Rams are largely exported for purposes of crossing with other breeds.

Lincoln. This is a very heavy sheep, competing with the Cotswold as the largest of British breeds. It has been improved in the past by crossing the old Lincoln, noted for its length and quality of wool, with the English Leicester. The face is pure white, and the head is surmounted with a tuft of wool, though not quite so abundant as in the Cotswold.

In body it is a large, square-framed sheep, very deeply fleshed along the back, and well developed in the hind quarters. The wool is long, lustrous, strong in fibre, and of superior quality. The rams of this breed are very popular with foreign buyers for increasing the size and wool production of their flocks, and of recent years high prices have readily been commanded by Lincoln breeders for first-class rams.

Romney Marsh, or Kent. This old and hardy breed has been associated for many years with the marsh land in the south of Kent known as Romney Marsh. They are white-faced sheep with black noses, and a small tuft on the forehead. They are also characterised by the somewhat Roman-shaped nose and low, compact forms on short legs. In their native district they seem to be remarkably immune from foot-rot, which is such a curse to most breeds.

Devon and South Devon Long Wool. The Devon is a local breed of Devon and Cornwall, which has been greatly improved in recent years. The face is white, and the body is long and wide, producing a carcase of excellent mutton, and also a heavy fleece of good wool.

Another local breed found in Devonshire, the South Devon long wool, lays claim to great antiquity. It is noted for its production of mutton and wool, and differs from the Devon long wool in being somewhat larger and clipping a heavier fleece. The face and legs are white.

Wensleydale. This large, high-standing sheep is found principally in Yorkshire, and sometimes spoken of as the Yorkshire Leicester. The breed is easily recognised by its style of carriage, and by the head, which has a greyish-blue face and small forelock. The wool also is of special character, being open and long, and divided into little " pirls." The rams are in favour for purposes of crossing with other breeds. Thus, when a Wensleydale is mated with blackface Highland ewes, it gives rise to the popular cross known as " Mashams."

Roscommon. A large, white-faced Irish breed, found principally in Connaught, the Roscommon approaches the Cotswold or Lincoln in size. These sheep produce fine carcases of mutton, and the fleece is long, heavy, and silky. The breed has been greatly improved by selection and by crossing with the famous Leicester.

Second in order of classification are the SHORT WOOLS, which comprise several notable breeds.

Southdown. The Southdown holds a similar position among the short wools to that held by the Leicester among the long wools; and the early type was improved and brought to its present standard of excellence largely owing to the efforts of John Ellman, of Sussex (1753–1832), who worked on Bakewell's lines. It cannot, however, be looked upon as a farmer's rent-paying sheep, except in its native district in the South of England, owing to the small weight of its carcase and the light clip.

The head is fine, but wide between the eyes; and the face is full, and of an even mouse-colour. The body is compact and deep, on short legs, and so symmetrical that it gives its owner the appearance of being the most graceful of all the native English breeds. The flesh is well let down on to the hock, and the twist is well developed, thus forming a good leg of mutton. The fleece is close, even, and short, and the wool of the finest quality of all the Down breeds. The skin should be of a clear, bright pink, and the whole appearance and carriage of the sheep should be such as to fascinate and engage the attention of the observer.

Hampshire Down. This breed is said to have originated by crossing the old Wiltshire horned sheep and the " Berkshire Knot " with the Southdown. The head is large, with a strongly marked Roman nose, the faces and legs being of a very dark brown or black. The body is long and deep, with well-sprung ribs. A slackness behind the shoulder was at one time a defect, but this has been largely got rid of. The fleece is fine and close, coming well up on to the head and round the ears. The early maturing properties of this breed have been greatly developed, and the ewes come in season sooner than most other breeds. On this account, also, the lambing season begins early—that is, soon after Christmas.

Dorset Down, or West County Down. This breed may be looked on as an offshoot of the Hampshire Down breed, which has been specially developed in Dorsetshire with the aid of Southdown blood. The breed is sometimes spoken of as the " improved Hampshire."

Shropshire Down. This is a medium-sized sheep, very similar in appearance to the Southdown, but the head is more massive, and almost entirely covered with wool, which comes on to the cheeks and right up round the eyes. The nose, which is the only part of the face exposed, is of a blackish-brown colour.

The breed originated from a cross between an old Shropshire breed known as the " Morfe Common " and the Southdown. It is hardy in constitution, feeds quickly, laying on a good covering of flesh on the valuable parts, and is very accommodating as to changes of soil and climate. It also grows a heavy fleece of first-rate quality, the wool being fine and close set. For these reasons it has become very popular, not only in Great Britain, but also in other countries, and the rams are much used for crossing purposes with other breeds.

Suffolk Down. This variety was the outcome of a cross between the old Norfolk horned sheep and the Southdown. Its head is very characteristic, being hornless and bare in appearance, while the face is covered with fine, coal-black hair, which extends well back behind the ears. It possesses a square frame, well covered with firm flesh. Its legs are clean and straight, black in colour, with fine, flat bone. The points of the breed are wealth of constitution, early maturity, a fine, close fleece, and excellent quality of mutton.

Dorset Horned. This is a very old white-faced horned breed found in Somerset, Dorset, and the western counties. The horns are characteristically curled, and the nostrils are pink. The ewes are noted for their fertility, and can be bred from twice in the year, but this is not often done, owing to the weakening effect it has on the constitution. The lambing time is October and November.

Ryeland. This local breed, of ancient origin, is found in the "Ryelands" of Herefordshire, and nearly disappeared a few years ago. The head has a white face surmounted by a top-knot, and the legs are also white. They are small sized, compact sheep, with a vigorous constitution and a short fleece of exceptionally fine wool. The rams are often used for purposes of crossing.

Oxford Down. This breed was formed by a cross between the Cotswold and the Hampshire, with the object of combining the weight of carcase and length of fleece of the former with the quality of mutton and fine wool of the latter. It is now in much favour in the English Midlands as the farmer's rent-paying sheep, and is well thought of by butchers. In fact, in some places it has ousted the original sheep of the district as a general-utility animal. The head is large, with the wool forming a top-knot and coming well on to the face, which is of a brown colour. The body is deep and long, and well fleshed. The fleece is heavier than in the other Down breeds, and the mutton is of good quality and not too fat.

Cheviot. Among the MOUNTAIN BREEDS, which come last in our classification, are some very hardy animals. The Cheviot holds an important place among mountain breeds. It is very hardy, and can adapt itself to changes of climate, so that when brought down from higher elevations it fattens rapidly on lowland farms. It is easy to recognise by its nose of Roman type, and face covered with short, white hair, which is carried back well behind the ears; its small and compact body is set on short legs of a white colour, and terminated by a long and well-hung tail. The wool is straight, and of moderate length, well covering the body. It crosses with the Wensleydale or Border Leicester, producing the famous "half-breeds" or "white-faces."

Scotch Blackface. An even hardier breed than the Cheviot, the Scotch blackface thrives on poor and exposed pastures at very high elevations. It is the typical hill sheep of Scotland, and is kept in enormous flocks on the high-lying sheep farms. Both sexes are horned, and the face and legs are mottled, showing black and white in well-defined patches. The fleece is long, strong, and coarse in texture, and consequently fetches a lower price than the finer wools, but there is a good demand for it in America. As might be expected, the breed is slow in coming to maturity, but the mutton, when grown, is of the finest quality.

Herdwick. A local breed found on the hills of Cumberland and Westmorland, the Herdwick possesses a great wealth of constitution. An old legend states that they are the descendants of some sheep saved from the wreck of a galleon which formed part of the Spanish Armada. The face and legs of the lambs are generally of a darker colour when dropped, but gradually change to white or steel-grey. The wool is strong and coarse, like that of other mountain breeds. The rams are sometimes horned. A peculiarity of the breed is that animals are sometimes found with an additional or fourteenth rib.

The Limestone and Lonk. The limestone is another local breed, found on the limestone hills in parts of Westmorland and Derbyshire. Both rams and ewes are horned, and the faces and legs are white. The wool is also white, and very long, and the mutton is of good quality. It is hardy and prolific, and it is possible to breed fat lambs for Christmas.

The lonk has its home on the hills of West Yorkshire, Lancashire, and Derbyshire. It is very much like the blackface in appearance, but is larger, and the fleece is shorter, finer, closer, and heavier, and the constitution is not so hardy. It is a horned breed, with a long, rough tail, and the face and legs are black or mottled.

Exmoor and Dartmoor. The Exmoor is a small, horned breed somewhat like the Dorset horned in appearance, but stronger in constitution. It is found in parts of Cornwall and Devonshire. The faces are white, with black nostrils, and the mutton is of first-rate quality.

The Dartmoor, another breed found in Devonshire, is hornless, of medium size, and very hardy. The face and legs are speckled, and it possesses a good fleece of soft, long, curly wool.

Welsh Mountain. This small, hardy, long-tailed breed is found on the hills throughout the Principality. The rams have gracefully curved horns, but the ewes are generally hornless, and their face and legs are white in colour. It has a great reputation for producing small, juicy carcases of mutton, which are highly prized on the London market. On the Welsh hills the original small breed exists, but in the lowlands its character has been somewhat altered, and its size increased by crossing with early maturing breeds.

Kerry Hill, Radnor, or Tanface. The Kerry Hill may be looked on as the most important of a number of local Welsh breeds which have recently come to the front. It is hornless, with a speckled or mottled face and legs and compact body. It produces a good fleece of fine wool, and carries its tail long.

The Radnor is an old Welsh mountain breed from Radnorshire. They are short-legged, hardy little sheep, with long tails, and produce a close fleece of fine wool. The faces and legs are speckled. The ewes cross well with Shropshire, Hampshire, and Oxford rams for the production of early lamb.

Clun Forest. This breed originated by crossing an old, tanfaced, native Welsh variety from the Clun district with the Shropshire. The head is small, and the face is black to a fawn colour; the horns are going out, but the sheep retain their long tails. The mutton is of excellent quality, and sold as "Welsh" on the London market. It is often crossed with rams of the early maturing breeds for purposes of getting fat lambs.

Penistone. The Penistone is a long-tailed breed, very similar to the limestone, and is found on the borders of Yorkshire, Lancashire, and Derbyshire, in the neighbourhood of Penistone. The faces and legs are white or light grey, and horns are generally present. The fleece is of medium length, silky in appearance, but inclined to be coarse in quality.

The General Management of Sheep. Various systems of sheep-farming are followed in different parts of the United Kingdom, the methods adopted depending on the soil and climate, and the special objects the farmer has in view. Thus, in the more mountainous districts in the north and west the "hill-breeding flocks" are found, wool being the

chief consideration. On chalk downs where there is plenty of room, lamb-breeding is often indulged in, the lambs being sold at the autumn fairs.

On arable farms which will carry sheep the "permanent flock" is the general practice. In this case it is usual to breed, rear, and fatten on the same farm, forcing on the lambs for sale as rams, or for turning them into mutton. Should the latter be the object, the tegs are fattened off on roots during winter.

A word must be said with regard to the influence which the introduction of root crops into the ordinary systems of farming had on the sheep industry of the United Kingdom. Before the turnip and swede became common farm crops, and helped to develop an intensive system of arable farming, there was little winter food for sheep and consequently their growth was somewhat slow. Now, however, with improved breeds and bulky root crops for winter keep, sheep can be fed from birth till they are ready for the butcher without a check, and in much less time than formerly.

In the case of grass farms in the vales, where the land is good, the "flying flock" is the usual custom, any sort of ewes being bought in the autumn to breed one crop of lambs. The ewes and lambs are then sold off fat at Easter or soon afterwards. It may here be noted that one of the principal factors of success in sheep-farming is to obtain the services of a good shepherd, who can be depended upon at all times, and whose sympathies are bound up in the interests of his flock. The chief points in the management of a flock may be dealt with under the following headings.

Lambing. Lambing takes place earlier in the southern counties of England than in the North, where the climate is less genial. The site for the lambing-pen should be chosen with care, and dry, sound ground, with a southern aspect, is essential. The lambing season is the most anxious time of the year to the sheep-farmer, as on the crop of lambs obtained depend the year's profits. It should be remembered that parturition is a natural process, and that it is a great mistake, in the anxiety to take every precaution, to over-pamper the ewes or to handle them unnecessarily.

The feeding and treatment after lambing should be such as to give the ewe's milking powers full scope. The best foods for this purpose are a few roots, such as turnips, swedes, mangel, or a little cabbage, together with clover, hay, and a small allowance of a mixture of oats and cake. Lambs are very hardy; and when they have plenty of milk, after a few weeks' shelter about the pen may be sent with their mothers to another part of the farm.

Weaning. Lambs may be weaned when from three to four months old. The exact treatment of ewes and lambs before and after weaning will depend very largely on the resources of the farm, and the object for which the lambs are intended. On arable farms, while with their mothers, the lambs should be encouraged to run forward through creeps to nibble the young shoots of turnips, and to eat a little mixture of oats, split peas, and linseed-cake. Thus when weaning takes place they will be already accustomed to feed by themselves, and the separation will affect them but little.

After weaning, lambs should be put on good pasture or seeds, and have a small allowance of corn. Ewes should, on the other hand, be run on poor grass to get rid of their milk. Lambs intended for the butcher must be forced along all the time, and are generally fattened off as tegs on roots during the winter, receiving at the same time an allowance of artificial food. Ewe lambs to be kept on for breeding purposes need only be run over the winter in healthy store condition.

Washing, Shearing, and Clipping. Washing is done in May or early June—about a week or ten days before the process of clipping. The object is to clean the sheep by removing accumulations of dirt, and thus make the wool bright. There is some difference of opinion among flockmasters as to the advisability of washing their sheep, owing to the damage that is sometimes done to them; but as washed wool is worth considerably more per pound than unwashed, the process is usually carried out on most farms. The operation of shearing and clipping follows about a week or so after washing. The time for this operation varies according to the climate, beginning in May in the South of England, and later as we go northward. The tegs are generally shorn first, the ewes following a week or two afterwards.

Dipping. The value of dipping is now fully recognised by farmers, and is carried out with the object of preventing parasitic attacks on sheep, such as the fly, ticks, and scab. Dipping is at the present time compulsory, and has to be performed at least once during the summer. Better results are obtained, however, if the sheep are dipped a second time, towards the autumn. A dip can be made at home, but it is generally more convenient to purchase a "patent dip." To carry out the operation a bath of some sort, either portable or fixed, must be made use of.

Towards the latter part of the summer it is the custom to go through the breeding stock to decide which animals shall be drafted and got rid of. The age at which a ewe is drafted will depend on her general soundness, good points, and the condition of her teeth. Draft ewes intended for the butcher must be pushed on as rapidly as possible, and they should receive extra food in the shape of cake and corn.

The Fleece. The value of a fleece will depend on its quantity, quality, and condition. In examining a fleece the best wool will be found over the shoulder in the region of the heart; the coarsest wool is situated on the thigh. The fleece should therefore be opened and inspected in these two places when judging its value.

Wool may be divided generally for market purposes into the following classes:

Carding wools are short-stapled wools, used principally in the manufacture of clothing and woollen goods. The Down wools, especially the Southdown, are good examples of this class.

Combing wools are long-stapled wools used for the production of worsteds. Lincoln, Cotswold, and other long-stapled wools belong to this class.

Carpet and knitting wools are long-stapled wools, coarse in fibre, such as that grown by the Scotch blackface.

These classes may be again divided into various grades according to the size or fineness of fibre. The quality of the wool will be determined by its softness, fineness of fibre, and soundness. As a rule, short-woolled sheep produce the finest wool.

The great difference a rise in the price of wool makes to the income of the farmer may be readily realised when we remember that some of the larger breeds clip 8 to 10 pounds or more per fleece, and estimate what this increased value means to the owner of a large flock when there is a rise of 4d. or 5d. per pound.

DRYSDALE TURNER

The Light Thrown by Radium upon the Origin and End of our Earth. The Rays and Energy of Radium.

RADIUM AND THE WORLD

THE revelation of radium has led us to believe that the human race may now expect many more million years of sunlight than we had hoped for ere the discovery of radium upset the accepted cosmical time-table. The accepted view as to the sun's heat was, as we have already seen, that it is produced by a continuous gravitational shrinking of his substance. Helmholtz, Lord Kelvin, and many other physicists have addressed themselves to this problem, and the verdict passed upon humanity was that it cannot expect more than 5,000,000 years to live—probably 3,000,000 would be nearer the mark. After that, assuming that the sun received no help from anything but his own shrinkage, he would be too cold to support life upon the earth. Reasoning from similar evidence the physicists were able to assign his age to the sun; but while they declared that he may be perhaps 25,000,000 years old, the geologists declared that the crust of the earth was far older, dating from hundreds of millions of years ago. There the controversy long stood. The late Marquis of Salisbury, in his once celebrated presidential address to the British Association, in 1894, made much of this enormous discrepancy between the two estimates. It served his purpose, which was to discredit the theory of evolution.

But if there be radium in the sun, then he has in it another and most potent source of his light and heat besides the shrinkage on which the physicists were calculating; and his age may well be as long as that which the geologists demand as necessary in the past for the formation of the earth's crust. Furthermore, if there be radium in the sun, there is no reason why he should not be vivifying a happy and fruitful earth ten or fifty or a hundred million years hence, instead of leaving posterity to die of frostbite after only three million years.

Let us glance for a moment at the reasons we have for believing that there is radium in the sun. In the first place, we have the fact, proved by the late Sir William Huggins and his followers, that suns and stars and comets contain just the elements that occur on the earth, the whole universe being thus made of the same material. Earth and sun were one in the nebula from which the solar system was formed, and therefore it would seem highly probable that any element occurring on the earth will also be present in the sun. A second reason for believing that there is radium in the sun is, as we have already seen, that its presence there would reconcile the disagreement between the cosmical time-tables of the geologists and the physicists, who are pluckily studying all time and all existence from the surface of this "lukewarm bullet," as Stevenson called the earth. A third reason is to be found in the fact that helium is known to be evolved from radium on the earth, and thus its presence in the sun suggests that there must be radium there also.

But the reader will ask whether there is not a very simple and definite manner of determining the answer to our question. If radium is truly an element, he will say, it must have a characteristic spectrum of its own. The lines characteristic of this spectrum should be recognisable in the spectrum of sunlight if radium be indeed present in the sun. Now, as a matter of fact, numerous observations have been made without obtaining any definite evidence from the spectroscope of the presence of radium in the sun. This fact, however, does not outweigh the positive arguments which we have already enumerated and others which are frequently being added to them; for it seems probable that the characteristic contributions which radium might be expected to make to the spectrum of sunlight may be absorbed by our atmosphere in such a fashion that they cannot be detected at its bottom where we live. There is nowadays, at any rate, no doubt that the sun gives out electrons just as radium does. One of the theories advanced for the formation of a comet's tail—a subject to which reference was made when discussing radiation pressure in the course on PHYSICS—was that these electrons hit a comet and develop its tail by causing its lighter parts to stream behind it, for a comet does not

develop a tail until it approaches the sun, and the tail is always turned away from the sun. The electrons given out by the sun are believed to strike our atmosphere, and thus, in certain conditions, to make the rare gas krypton that exists in the topmost layers of the atmosphere to become luminous; and that, it is believed, is the cause of the phenomenon known as the *Aurora Borealis*.

The Cooling of the Earth. But, as a matter of fact, we need not wait for a positive answer to our question—at any rate in so far as we ask it in the desire to explain the discrepancy between the two rival estimates of the age of the earth. Sir Ernest Rutherford, of the University of Manchester, the most distinguished pupil of Sir Joseph Thomson, of Cambridge, has gone far to solve this difficulty for us. One of the means by which Lord Kelvin estimated the age of the earth consisted in a calculation of its "secular cooling"—the rate at which the heat is radiated into space. But Lord Kelvin could not take into account, when he made that calculation, the remarkable fact discovered by Rutherford, which is that radium—or, at any rate, radio-active matter is, so far as his observations have hitherto gone, a constant constituent of the materials that compose the earth's crust. Now, Rutherford has calculated the proportion in which radium occurs in the earth's crust, has estimated the amount of heat which such a quantity of it must produce, and has actually shown that, if his calculations be correct, the radium of the earth's crust suffices by its production of heat completely to replace and thus compensate for the heat which the earth constantly loses by radiation into space.

The Rays of Radium. Those immature atoms of helium, as we now believe them to be, which physicists call the *Alpha* rays, consist, of course, of material particles; they are not mere vibrations in the ether, like sunlight, the Rontgen rays, heat rays, electric waves, and most of the others with which readers of the course on PHYSICS are more or less familiar. But the emission of these rays, and the production of the celebrated emanation to which they give rise, constitute only one of the many activities of radium. There is a great deal more that goes on within the spinthariscope than the zinc sulphide paper reveals to us. The *Beta* rays, so called, must later be discussed, but we may here dispose of the third variety of rays which are constantly being given off by radium, and which are known as the *Gamma* rays (Alpha, Beta, and Gamma are, of course, the first three letters of the Greek alphabet). Now, the *Gamma* rays of radium are either identical with the Röntgen rays, which are now almost a commonplace, or are at any rate nearly identical with them. We may guess that it is the occurrence of these rays that explains the similarity, in their unique and beneficent action upon certain diseases, between radium and the Röntgen rays. Like these latter, the *Gamma* rays have the most extraordinary penetrating power. It is said that they can be detected after passing through five inches of armour plate. Not only does radium give out these rays, but it has the power of picking up, so to speak, any Röntgen rays that may be about. If you are looking at a piece of radium in the dark through a fluorescent screen, you may notice that it shines more brightly than before if Röntgen rays are being generated in the same room, showing that it has the power of picking them up and giving them forth again in an altered form.

What Half a Pound of Radium Would Do. But in addition to the three kinds of rays to which special names have been given, radium is ever giving out a large quantity of those rays which we call *heat*. Whatever the temperature of its surroundings, it is always a little hotter. So powerful is this action, and so nearly inexhaustible, that if you could obtain a sufficient supply of radium—probably half a pound would be quite enough—it would keep a room warm, not merely during your lifetime, but for hundreds of generations after you. We may note, however, that, as the late Professor Curie remarked, one would not care to be in the same room as half a pound of radium.

Fastest Moving Matter Known. And now we turn to what are, in some respects, the most important products of radium. Like the *Alpha* rays, the *Beta* rays consist of particles. It is no easy matter to say, however, of what the particles consist. The particles that constitute the *Alpha* rays may freely be described, indeed, as particles of matter. As we have seen, they are really atomic particles. But the particles that constitute the *Beta* rays are of proportions almost infinitely smaller than those of the smallest atom. The name applied to them by their most distinguished student, Sir Joseph Thomson, is *corpuscles*: the most popular name, however, is *electrons*. These fly out from the radium at a most amazing speed. Sir Oliver Lodge has said of them, "Three hundred times faster than the fastest flying star, they are the fastest moving matter known." Until the discovery of radium, it was thought that the greatest speed ever obtained by matter was that of certain of the "runaway stars." Arcturus, for instance—whom everyone should know who can recognise the Great Bear—moves at the rate of about one hundred miles a second, we used to be told, but that is a mere dawdle compared with the speed of these electrons.

Matter and Electricity. Now, each of these electrons, or corpuscles, carries with it a tiny charge of negative electricity. They are believed to be all of the same size; and the size is the same whether the electron be given out by radium or by thorium, or by uranium, or by any other radio-active substance. Hence it is that these substances are able to affect a delicate indicator of electricity; and it was by this means that Madame Curie, under the guidance of her husband, was enabled to discover radium. She began with two tons of pitchblende, the mineral in which radium is principally found, and ended some months of

hard work by obtaining one-tenth of a grain of radium bromide. This property of affecting an electric indicator was the only guide and test that she had in tracing this minute quantity of the unknown substance she was seeking.

We have said that the electrons *carry* a charge of negative electricity, but now it seems probable that each of them *is* a charge of negative electricity, or, indeed, is *an atom of electricity*. And when we go on to inquire where these electrons come from, and what they are doing before they leave the radium, we reach the amazing conclusion that atoms of matter are made of atoms of electricity! As a result of the revelations of radium, not only do we know that one kind of matter may be changed into another, but that matter itself consists of electricity.

The Marvels of an Atom. Readers of this and its companion course [PHYSICS] are already familiar with Lord Kelvin's estimate of the size of an atom. Roughly speaking, we may say that, if a drop of water were magnified to the size of the earth, the atoms within it would be somewhere between the size of small shot and cricket balls. This gives some faint idea of the size of an atom. But now imagine an atom of radium magnified to the size of St. Paul's Cathedral. Under such circumstances it would appear to consist of perhaps one hundred and fifty thousand tiny particles, each of which is one of the electrons we have been speaking of, and the size of those electrons would be about the size of one of the full stops on this page. Try to realise, if you can, from Lord Kelvin's illustration, what the size of an atom is, and then try to realise that the ratio of an atom to an electron—the ratio of an atom of matter to one of its constituent atoms of electricity—is the ratio of St. Paul's Cathedral to a full stop. Obviously one hundred and fifty thousand full stops would not fill St. Paul's Cathedral. And so far away from one another are the electrons in an atom that the relative distances are comparable to those between the planets of the solar system. Relatively to their size, the electrons are as far from one another in this inconceivably tiny atom as the earth is from Mars, which has an average distance from us of sixty millions of miles.

The Atom and the Solar System. This is by no means the only resemblance between an atom—or atomic system, as we should call it—and the solar system. Just as the planets are revolving round a centre, so the electrons in each of the atoms that go to make up those planets are also revolving round an atomic centre—revolving at a speed hundreds of times faster than the speed of the planets which they compose. And it is supposed that the electrons must frequently collide with one another in their mad race within the atom, and the result of these collisions is to expel some of them from the atomic system. The electrons thus expelled constitute the *Beta* rays of radium. So small are the electrons, as compared with the atoms of ordinary matter, and so great is their velocity, that they pass through such a substance as the brass tube of the spinthariscope almost as if it were not there. The *Alpha* rays consist of bigger particles, and they are stopped with ease, but the *Beta* rays need a considerable thickness of matter to arrest them. But when they are arrested they can be shot forth again, just as they were from the radium itself. This explains the fact that ordinary substances, such as glass, which have been kept near radium, themselves become radio-active after a time. And this is what makes one think that there is an analogy between radium and genius. Both get their energy from within, and both can impart some degree of their powers to their neighbours.

A New Source of Energy. This property of evolving power within itself is one of the most extraordinary facts about radium. At first it was thought to get its power from sunlight, or from some sort of unknown waves in the ether. Then Sir William Crookes thought that the molecules in the air might constantly be striking the radium and so be imparting energy to it. But now we know that the energy of radium is derived from the motion of its electrons. And this is a new source of energy, immeasurably greater than any which has hitherto been known.

The ingenious suggestion of Sir William Crookes that radium takes up the kinetic energy of the gases of the air is now known not to meet the requirements of the case. The view of Lord Kelvin that radium obtains its power by absorption of sunlight or of some other form of waves—known or unknown—in the ether was soon abandoned even by its distinguished author, who ultimately gave his adherence to another view, now established beyond dispute and known as the *disintegration theory* of Sir Ernest Rutherford. This is the theory the truth of which we have here assumed all along. It is the view which asserts that the atom of radium itself is the seat of gigantic energies which are quite adequate to explain all the energy-producing properties of radium, without the need of any assumption that the radium really obtains its energy from without. This theory further maintains that the external energies of radium can be manifested only at the cost of its internal energies. If, indeed, this were not so, there would be doubt thrown upon the doctrine of the conservation of energy. Thus, we believe it is only in virtue of the disintegration of its atoms that radium is enabled to exercise its remarkable properties. Hence the name given by Rutherford to this brilliant theory which he has now established.

Radio-activity is Universal. Radium is, of course, by far the most powerfully radio-active of all known bodies. It can be obtained with a radio-activity considerably more than a million times as great as that of uranium. Thorium also is very definitely radio-active. To these we may add the names of polonium and actinium, so-called, though there is now little doubt that these are merely names for the transient products of the disintegration of the radium atom.

But the truth is beginning to be recognised that radio-activity is not confined to the obviously radio-active elements. The wider our inquiry, the more certain does it appear that radio-activity may be found wherever we look closely enough for it. Even ordinary air is radio-active, while the soil-air and that found in cellars and caves is still more so. Deep well-water at Cambridge was found to be radio-active, and also the waters at Bath and in many other places. There are, of course, two possible explanations of this fact. It may be, in the first place, that minute traces of radium or of one of the other markedly radio-active elements are distributed throughout all other forms of matter. Or, on the other hand, it may be that all matter is radio-active in itself. But if this be so, how are we to explain the very marked differences in the degree with which this property is manifested? The explanation is not far to seek. The three most markedly radio-active of all the elements are the heaviest three elements. Radio-activity must be regarded as an intrinsic property of large and complex atoms. Of course, these terms are relative, and there is no inherent reason why we should suppose that even the simplest and smallest atoms, such as those of hydrogen and helium, are destitute of this property. But if radio-activity be an indication and consequence of the disintegration of the atom, it is only reasonable that it should be manifested in greatest degree by those very heavy and complex atoms which have a very long range of consecutive changes before they are resolved into simpler bodies.

Radium and Natural Selection. In a previous paragraph we hinted very briefly that the law which Darwin called *Natural Selection*, and Herbert Spencer called the *Survival of the Fittest*, may possibly have its realm of application in chemistry as well as in biology. We can readily understand how it might be applied to chemical compounds: innumerable compounds may be formed in the universe, but only the more stable ones will tend to persist.

Now that radium has revealed to us an entirely new conception of the origin and history of atoms, the question arises whether natural selection is not also applicable to them. The idea of natural selection is far older—ages older, indeed—than Darwin's application of it to organisms in 1859, or Spencer's application of it to societies eight years before. Indeed, the very first occurrence of this idea, so far as can be discovered, must be credited to the Greek thinker Empedocles. Reflecting upon the atoms conceived by his master, Empedocles is reported to have thought that innumerable species of atoms would be born, but that only those would survive which were best adapted to the conditions of the environment. Thus it was of atoms that the idea of the survival of the fittest was first conceived, and it is again to atoms that it has most lately been applied. The obvious reason why there is so little radium in the world is that its atom is unstable. Specimens of it are constantly being produced, but they cannot survive in the conditions in which they find themselves. We must thus regard the eighty or more different kinds of atoms with which we are acquainted as the more or less stable survivors from an absolutely indefinite number of possible atoms, most of which may have come into existence again and again, but which, like the dodo or the mammoth, have been exterminated by natural selection.

The Small Supply of Radium. The reader who realises that in radium we have discovered a source of almost inexhaustible power may be inclined to ask to what uses it has been turned. But in the first place it is necessary to note that the total amount of radium that has hitherto been isolated is extremely small. The use of the word *isolated* leads us to observe, in passing, that radium has not yet been obtained in its elemental form. It is known merely in the form of its simpler compounds, especially the chloride and bromide. But even of these the total amount yet obtained is almost ridiculously small. The difficulties of obtaining them are enormous; and though the process has been considerably improved since Madame Curie first performed it, there are still only a few grammes of radium salt in isolation anywhere. Thus, while we may easily demonstrate that, let us say, half a pound of radium would drive an ocean liner for decades or centuries, the realisation of such speculations is not within the range of practice. Hitherto the direct utilisation of the energy of radium has been accomplished only for purposes of demonstration, as, for instance, in the radium clock. But, as we have already noted, radium has been turned to practical purposes in medicine and surgery.

Radium and Living Matter. Needless to say, the action of radium upon different forms of living matter has been the subject of close inquiry during the last decade and more. So far as the very lowest forms of life are concerned, it seems that under certain conditions radium acts as an antiseptic, though not a particularly potent one. Its powers in this direction have only recently been analysed. On the other hand, it is quite certain that, under particular conditions, which we do not yet understand, the very radium which in other circumstances destroys malignant tumours has a tendency to produce them, apparently having a stimulant action upon certain forms of living matter. The same paradoxical facts have been observed in the case of the Röntgen rays. It would certainly be an amazing thing if radium did not exert certain influences upon living matter. If we consider that everything in its neighbourhood is exposed to the constant evolution of heat, to a constant bombardment by particles of atomic size, and by the sub-atomic, negatively electrified particles which we call electrons, and also by the constant reception of the *Gamma* rays, we can scarcely doubt that living matter must be very markedly and very variously affected by its influence. In a later section the most blessed and surprising value of radium in malignant disease must be referred to.

C. W. SALEEBY

European Nations Settling Towards their Present Forms. The English Loss of France. The Rise of the Hapsburgs.

PASSING OF THE AGE OF CHIVALRY

THIS period might fitly be called the Autumn of Chivalry and the Spring of Literature and Art. There are no more Crusades; the spirit of knight-errantry is departing; war seems to be often a sordid speculation on the value of the ransoms that may be extorted from wealthy prisoners. On the other hand, the young languages of Europe are beginning to bud and put forth leaves, as the truth dawns upon men that poems and histories may be written in other languages than Latin, that even the despised vernacular is a possible literary instrument. To this period belong the names of Dante, Petrarch, and Boccaccio in Italy, of Froissart in France, of Chaucer and Langland in England. In the history of art we have a catalogue of illustrious names from Giotto to Fra Angelico; in architecture, though Norman and Early English lie behind us, the beautiful Decorated and stately Perpendicular styles are to come.

Nor ought we in this connection to forget the services which the fresh enthusiasm of the young Mendicant Orders rendered both to literature and to art. Both Dominic and Francis lived in the eleventh and twelfth centuries, but the influence on the intellect of Europe of the orders which they founded was most fully felt after their deaths, and was certainly mighty throughout the later twelve hundreds and the two following centuries.

The Friars—as the Mendicants were called to distinguish them from their rivals, the more old-fashioned and conservative monks—chiefly known by their two most popular representatives, the Dominican Black Friars and Franciscan Grey Friars, swarmed into the universities now rising into eminence throughout Europe, and contributed the most celebrated names to the list of professors of scholastic theology, who, however the world may have now outgrown their teaching, evidently possessed some of the strongest and keenest intellects of their day. Of the five greatest schoolmen, Albert the Great and Thomas Aquinas were Dominicans; Buonaventura, Duns Scotus, and Occam were Franciscans. It was from the bosom of the Franciscan Order, also, that the philosopher sprang who anticipated in some degree that strictly scientific method which, in the hands of his mighty namesake, was one day to vanquish the word-splitting dialectic of the schoolmen, Roger Bacon, the "Doctor Mirabilis" (1214-1294).

In reviewing the course of these two centuries, we may very lightly touch upon the well-known events in the history of our own country. England under the early Plantagenets had not been a stranger to the storm which had swept over the ecclesiastical sky in Southern Europe. She, too, had found her Hildebrand in Becket, and had witnessed her Canossa when the abject John submitted to declare himself the vassal of the Pope. Perhaps, also, it may be said that she had not been without her Guelfs and Ghibelines when Simon de Montfort, popularly known as the creator of the English House of Commons, vanquished Henry III. at Lewes, and was himself vanquished by Prince Edward at Evesham.

In 1272, six years after the battle of Benevento, Edward Longshanks, greatest of the Plantagenets, ascended the throne. In his reign of thirty-five years he did many noble deeds both as statesman and as legislator. Even his conquest of Wales, notwithstanding some ungenerous harshness, must be reckoned among his praiseworthy exploits; but his unsuccessful attempt on the liberties of Scotland, his endeavour to convert the friendly superiority which Scotsmen were willing to grant him into the strictest, harshest tie of feudal vassalage, wrought untold harm to the England which he surely loved.

From the year 1296, when the galling acts of Edward drove the luckless John Balliol into revolt, down to 1603, when James Stuart mounted the English throne, it may almost be said that there was never lasting peace between the two countries, only wars and precarious truces, raids and counter-raids, and, above all, a continual and most natural tendency on the part of Scotland to ally herself with

England's other enemy, France. There was thus always a foe at England's back door who would not have been there had Edward I shown somewhat less of the qualities of a sharp attorney in his dealings with the sister kingdom.

The Hundred Years' War. Though John "Lackland," by his cowardice and cruelty, had lost his father's inheritance of Normandy, the Plantagenets, till the close of our present period, never entirely quitted hold of the magnificent dower which Eleanor of Aquitaine brought to Henry II., and these possessions in the south-west corner of France often furnished a base for the operations which they undertook in what has been forcibly, if not quite accurately, called the Hundred Years' War between England and France. That war began with the invasion of France by Edward III. in 1339, and it ended with the defeat of Talbot before Castillon in 1453, the very year which for another reason has been chosen as the close of our present period. During that age of strife the English won three memorable victories—Crecy, Poitiers, and Agincourt.

We are perhaps too much inclined to forget their defeats; that of Beaugé (1421), where the Duke of Clarence, brother of Henry V., was slain; that of Patay (1429), where Lord Talbot was vanquished and made prisoner by the heroic Joan of Arc; his final defeat and overthrow, as above mentioned, at Castillon. The two proudest days for the English invaders were March 24th, 1359, when, by the Treaty of London, the captive king of France yielded to Edward III. in full sovereignty all that Henry II. had ever ruled as vassal of the French Crown, Normandy, Brittany, Anjou, Maine, and Aquitaine—in other words, a full half of France; and, again, December 16th, 1431, when, apparently with the consent of the greater part of the French nation, weary of the feuds of Armagnacs and Burgundians, the English child, Henry VI., was proclaimed "King of England and France, our sovereign lord."

A Sham Title which Napoleon Shattered. That title, King of France, so soon to be rendered a vain show by the enthusiasm and courage of the Maid of Orleans, was clung to with ludicrous tenacity by many generations of English sovereigns, even by James II., when he was a throneless exile at the court of the real king of France, Louis XIV., and was abandoned only in the days of our grandfathers at a time when there was no king in France, and that country, under a ruler mightier than any of her kings, was engaged in a life struggle with England.

The Consolidation of France. The high-water mark of England's dominion in France was soon succeeded by a steady and continuous ebb of the tide. It was by a series of petty reverses more than by any great victories that the English intruders were edged out of France, until at last, at the end of our present period, Calais only remained to them. But the Hundred Years' War left in one way a favourable impress on France. As the Danish invasions had consolidated England, so the long misery of the English invasions unified and strengthened the national feeling of Frenchmen. When the Hundred Years' War began, the men of Aquitaine scarcely looked upon the Parisians as their fellow-countrymen. When it ended, they recognised the necessity of their position and accepted, if somewhat grudgingly, Charles VII. as their sovereign lord.

The advantage which France won, however painfully, from this struggle for her national existence was to some extent neutralised by the folly of her kings, especially of John and Charles V., in granting enormous "appanages" to members of their family, which made them almost independent sovereigns and tended to keep alive sectional and provincial jealousies. It was owing to this mistaken policy that the rival houses of Burgundy and Orleans were able to distract their country by that fatal feud which, far more than the English valour at Agincourt, laid France prostrate at the feet of Henry V.; and even when peace was restored and the English invader expelled, the reconciled Duke of Burgundy was terrible to his sovereign lord, whose power he gloomily overshadowed.

The Bold Burgundians who Overshadowed France. Lords of Burgundy by inheritance, and of the Netherlands by marriage, these mighty seigneurs, whose beautifully carved tombs, a marvel of late mediæval work, are the glory of the cathedral at Dijon, became the traditional enemies of their French cousins, traditional allies of the English kings, whose country was closely connected with their country by the ties of commerce. The very surnames of these men mark their militant position—Philip the Bold, John the Fearless, and Charles the Rash; they were men born to be assassinated or slain in battle.

The Beginning of the Proud Hapsburgs. Eventually, as we shall see, the fortunes of the heirs of Burgundy were closely intertwined with those of the house of Hapsburg. The uprise of this house of Hapsburg, by no means the oldest though one of the proudest of European royalties, was all accomplished in the period now before us. When the mighty house of Hohenstaufen fell (1254) there was for a time anarchy in Central Europe. Phantom emperors, an English prince (Richard Duke of Cornwall), a king of Castile (Alfonso the Wise), and others flitted across the stage, but none of them exercised any real authority till in 1273 the Electors chose for emperor a Swabian knight of respectable position named Rudolf of Hapsburg, who was accordingly crowned with the imperial diadem in Charlemagne's city of Aachen (Aix-la-Chapelle). The territories—of very moderate extent—over which Rudolf ruled, as well as his castle of Hapsburg, were situated in the valley of the Aar, in the north-east corner of what is now Switzerland. It is worthy of note that the cradle of that dynasty, which has pre-eminently represented the monarchic principle in Europe, and the cradle of the first, and we might almost say the typical, Teutonic republic were situated within a short day's journey of one another.

THE CHARGE OF THE FRENCH KNIGHTS AGAINST THE BOWMEN OF ENGLAND AT CRECY

THE SURRENDER OF KING JOHN OF FRANCE TO EDWARD THE BLACK PRINCE AT POITIERS

The Foundation of Hapsburg Greatness. Rudolf, who had been chosen partly on account of his very insignificance, proved himself a stronger and abler ruler than had been expected. He humbled to the dust the proud Ottokar, king of Bohemia, in whose court he had once served, and after his second victory over him rent away from his slain rival the duchies of Austria, Styria, Carinthia and Carniola, a goodly inheritance which he bestowed upon his own son, thereby laying the foundation of the greatness of the house of Hapsburg. Unlike his recent predecessors he was on friendliest terms with the Pope, but no invitations or exhortations could induce him to enter Italy, "that lion's cave, into which he saw many footsteps tending, but from which none returned."

There was as yet no willingness on the part of the Electors to permit the empire to become hereditary in the Hapsburg or any other line. With difficulty did Rudolf's son, Albert, win the imperial crown, which he held for a few troubled years, and after his death in 1308, there was no emperor of the house of Hapsburg reigning with undisputed title for 130 years. For twelve years (1314–1325) Frederic of Austria was endeavouring, generally with little success, to vindicate his right to the imperial title against his rival Louis of Bavaria.

This interval, somewhat tantalising to the student who knows that it will end in the establishment of the empire in the Hapsburg line, was filled chiefly by emperors of the house of Luxemburg, such as Henry VII., the ruler for whose advent into Italy Dante longed, and who, when he came, was crowned emperor in Rome, but after three years' stay in Italy, years of mingled success and failure, died, as men said, from poison administered in a cup of sacramental wine. Henry's son, the blind King John of Bohemia, who fought so bravely at Crecy, was never emperor, but his grandson, Charles IV., the Parson's Emperor, as he was called, because of the ecclesiastical influence which secured his election, by the celebrated Golden Bull (1356) weakened the prerogatives of the Imperial Crown and established the Seven Electors as almost independent sovereigns.

The Seven Electors. These Electors were three ecclesiastical potentates in Rhineland, the Archbishops of Mayence, Cologne, and Treves, and four secular princes, the Count Palatine of the Rhine, the Margrave of Brandenburg, the King of Bohemia (who after 1437 was generally a Hapsburg), and the Duke of Saxony. By this instrument, as Mr. Bryce has well said, Charles IV. legalised anarchy and called it a constitution. Yet it is interesting to note the prevalence at this date in Central Europe of a form of government which has now entirely disappeared. In the thirteen hundreds, and for some time longer, Germany, Bohemia, Hungary, and Poland were all elective monarchies.

THE ENGLISH LINE OF BATTLE AT AGINCOURT

The Freeing of Switzerland. In other ways at this time some new and interesting experiments were being made in the art of government. Albert of Austria, son of Rudolf, to whose short tenure of the imperial dignity reference has been made, was successfully resisted (1307–1308) by the inhabitants of the

MEDIAEVAL CONFLICTS IN NORTH & SOUTH

A SCENE IN THE WAR OF WALDEMAR IV. WITH THE HANSEATIC TOWNS IN THE FOURTEENTH CENTURY

THE SICILIAN VESPERS—THE MASSACRE OF THE FRENCH AT PALERMO IN 1282

four Forest Cantons which cluster round the Lake of Lucerne. This was the germ of the Swiss Confederation which at Morgarten in 1315, and at Sempach in 1386, defeated the knights and men-at-arms sent against them by the Austrian princes, and for ever established the independence of Switzerland.

The Dawn of the Power of Trade. During the same century, the century of the thirteen hundreds, the confederacy of German merchants known as the Hanse Towns—the chief of them Lubeck, Hamburg, and Bremen—were fitting out fleets and armies, and comporting themselves like sovereign princes on the shores of the Baltic. By the treaty of Stralsund in 1370 they obtained from Waldemar IV., king of Denmark, the right to receive for fifteen years two-thirds of the Danish revenues and a provision that thereafter none of his successors should ascend the throne without the consent of the Hansa. When, in 1397, the daughter of this king, Waldemar, Margaret, "the Semiramis of the North," succeeded in uniting Denmark, Sweden, and Norway by the Union of Calmar (1397), the power of the Hanseatic League was somewhat abated, but to the end of the period under consideration it remained a most important factor in the politics of the Baltic States.

When Austria Claimed the Earth. Returning for a moment to the Hapsburg princes, we have to note that at last, in 1437–1438, a Hapsburg, Albert II., having married the heiress of the house of Luxemburg, was elected king of Bohemia, king of Hungary, and emperor, but he held these dignities only for a short time, dying in 1439. On his death, his cousin, the Duke of Styria, was raised to the empire as Frederic III., and thenceforward the imperial title was borne by none but his descendants for nearly four centuries, at the end of which time the empire itself ceased to be. Frederic III., himself a dull, slow man, with the heavy under-lip of the Hapsburgs, dabbled in alchemy and astrology, and derived, apparently from these studies, an intense conviction of the proud destiny of his house.

The Cradle of the Hohenzollerns. We may here remark that the Hohenzollern princes, who are now represented by the Emperor William II., obtained possession of Brandenburg, which has now been for many centuries the stronghold of their dynasty, in the year 1417. The Hohenzollerns, like the Hohenstaufen and the Hapsburgs, came originally from Swabia, that picturesque south-west corner of Germany, watered by the Rhine, which almost alone of the provinces of Germany was once part of the Roman Empire.

We recross the Alps and inquire what are to be the fortunes of Italy now that the Swabian sons of her Norman conquerors are vanished out of the land. Not absolutely, however, did they vanish when Manfred fell at Benevento. In 1268, Manfred's nephew, the gallant youth Conradin, son of the Emperor Conrad IV., descended into Italy with a large army. For a time fortune smiled upon him, and even when he joined battle with his enemy, King Charles, near Tagliacozzo, under the shadow of the Sabine Mountains, the battle at first went in his favour, but a well-planned ambuscade threw his army into disorder. Victory was for Charles, death on the field of battle for a multitude of German knights, the followers of Conradin; a more ignominious death at Naples, by the hands of the executioner, for Conradin, a captured fugitive.

The Call for an Avenger. It was considered a foul and unknightly deed when the Frenchman thus punished the captive lad who had but striven to regain the inheritance of his fathers; and later writers described how from the scaffold he threw his gauntlet down on the pavement of the Piazza del Mercato, crying, "Take that glove to him who will avenge me." Criticism has thrown doubt on this story, but there is no doubt that it was as the avenger of Conradin that his cousin by marriage, Pedro, king of Arragon, Manfred's son-in-law, before long appeared upon the scene.

Charles of Anjou, a hateful man, vexed his subjects with all manner of new taxes rigorously exacted; but even more than by pecuniary oppression the souls of the people, especially the hot-blooded Sicilians, were fired by the insolence of the French soldiers who swaggered as conquerors among a nation whom they despised. Vengeance slumbered for fourteen years, but during all that time the gauntlet of Conradin—real or metaphorical—was being treasured at the court of Arragon, and when at last, on the evening of Easter Monday (March 30th, 1282), the lewd insults of a French soldier to a Sicilian matron roused the people of Palermo to revolt, King Pedro was ready to aid them.

The Avenger Arrives. The massacre of all Frenchmen, which began with the ringing of the vesper bell at Palermo, was accomplished with dreadful thoroughness all over the island, and is known to history as the Sicilian Vespers. Charles of Anjou, of course, did not surrender the beautiful island without a struggle. Messina endured a terrible siege, but survived untaken. Pedro of Arragon was declared king, and successfully established his kingdom, which was held by his descendants down to our own time.

The Kingdom of "Both the Sicilies." Charles remained the king of Naples and of all Southern Italy, which by a legal fiction received also the name of Sicily, and hence came that absurd title, "King of Both the Sicilies," which, when the two kingdoms afterwards came together under descendants of the king of Arragon, was borne by their rulers.

Thus, as far as Sicily was concerned, the arrogant French invader was repelled, but, alas! freedom had to be purchased at the cost of submission to another foreigner, a Spaniard. The conditions were similar to those which inspired Byron's lines addressed to Italy:

> "The stranger's sword
> Is thy sad weapon of defence, and so,
> Victor or vanquished, thou the slave
> of friend or foe."

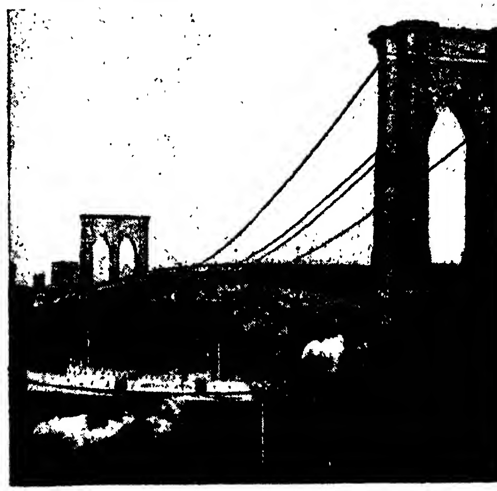
Thus the fall of the Hohenstaufen brought little peace to Italy. THOMAS HODGKIN

THE MAID ACHIEVES HER GLORIOUS AIM

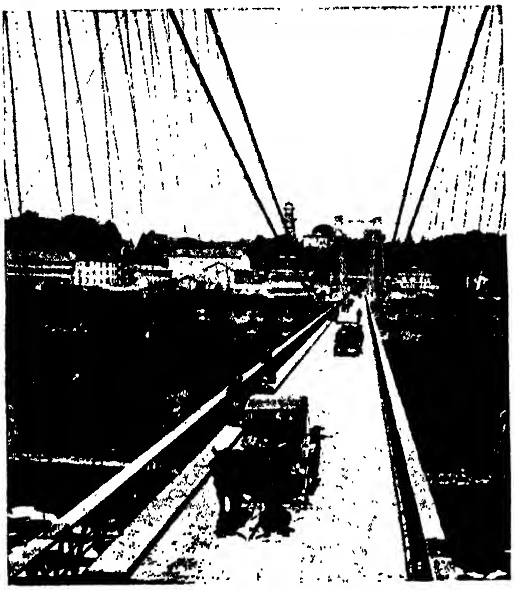
JOAN OF ARC AT THE CORONATION OF CHARLES VII. OF FRANCE IN RHEIMS CATHEDRAL

FIVE GREAT TRIUMPHS IN BRIDGE-BUILDING

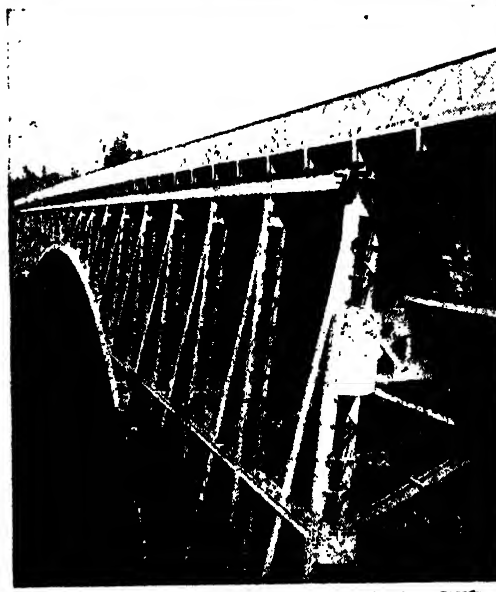
HAWKESBURY BRIDGE, NEW SOUTH WALES



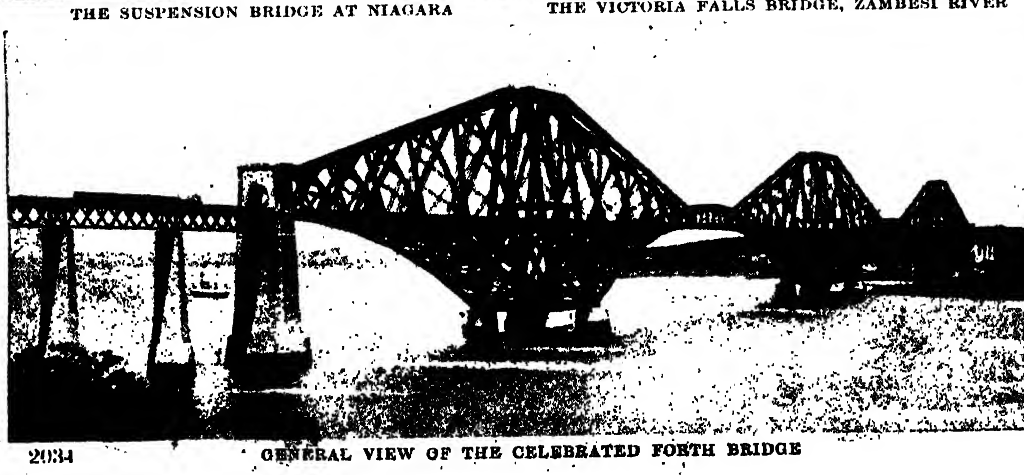
BROOKLYN BRIDGE, NEW YORK CITY



THE SUSPENSION BRIDGE AT NIAGARA



THE VICTORIA FALLS BRIDGE, ZAMBESI RIVER



GENERAL VIEW OF THE CELEBRATED FORTH BRIDGE

Trussed and Arched Bridges. Suspension and Girder Bridges. Bridge Foundations. The Cantilever Principle. Movable Bridges.

THE BUILDING OF BRIDGES

THE earliest bridge was formed by the accidental falling of a tree across a stream, probably by the scour carrying away the earth and undermining the roots, so that the tree overbalanced and fell on that side. Following the example set by Nature, it is an easy step to form a good bridge for a short span by placing two or more tree-trunks side by side across a stream, and we may readily suppose that the branches were lopped off and used in short lengths laid across the trunks to form a very passable footway. A rustic bridge not far removed in principle from that described is shown in 1. We may grant this much as due to instinct or imitation; it was not engineering.

When, however, a wider span had to be crossed, so that some form of trussing was required, the necessity for invention arose, and with it the first bridge engineer.

The simplest kind of trussing, and probably the earliest, would be what we now call in its developed form *a king post truss*, but for stiffening the bridge no struts were wanted, so that with the addition of a handrail it would appear in the form shown in 2. A greater interval as regards intelligence seems to exist between this form and the inverted truss [3], but we may account for its first origin by the overturning of one of the other trusses, and then the happy thought that instead of one of these on each side of the bridge, a series might be laid side by side to form a wider bridge, and so enable heavier traffic to pass from one side to the other. From these two forms it is a short transition to the more complex forms of the *queen post truss* [4] and the corresponding *inverted truss* [5]; and the observed effect of a travelling road in depressing one strut and raising the other would lead to the cross-bracing in the central bay [6].

An early type of timber bridge was one built in Glasgow, in 1832, in 34 ft. spans, as shown in 7. It is very simple in construction, and upon the same principle as the ordinary stone-yard gantry. Many timber bridges of this character exist across canals in various parts of the country, and there are also some across the upper reaches of the Thames. We need not trace the gradual improvements that were made, even if it were possible; it will suffice to notice the modern form of timber bridges for large spans, used principally for pioneer work in America, and shown in 8 and 9. In some of the larger spans wrought-iron rods or long bolts are used for the tension members; they overcome in a very simple manner the difficulty of framing timber to withstand tensile stress. Some of these bridges are covered by wooden roofs.

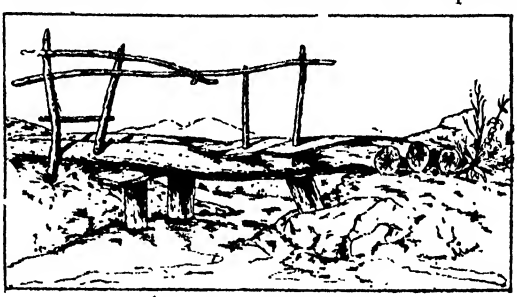
To avoid the frequent renewal of bridges owing to the decay of the timber, or the accidental destruction by fire, brick and stone arched bridges have been in use from very early times, and some beautiful structures have been erected. In London we have Waterloo Bridge, of granite, with nine elliptical arches, all of 120 ft. span and 35 ft. rise; and London Bridge of granite, of five spans, the centre one 152 ft. 10 in. span and 37 ft. 10 in. rise, as shown in 10, and the other spans somewhat smaller. This bridge was erected at an original cost of nearly half a million sterling, and was subsequently widened by extending the footway over stone cantilever brackets on each side. A stone bridge of 200 ft. span over the Dee at Chester is shown in 11.

A large masonry arch bridge is the viaduct at Plauen, in Saxony, which bridges the valley of the Syra, and was only recently completed. It has a clear span of 295·4 ft., and a rise of 59·04 ft., and carries a roadway 36·8 ft. wide with two pathways each of 9·84 ft. width. The arch forms a composite curve, being struck from five centres, the crown having a radius of 344·4 ft., the springings 192 ft., and the haunches 98·7 ft. radius. It was designed for loads which include a train of 15-ton waggons, or of three steam-rollers, weighing 23 tons each. The arch ring is built of bluish-grey stone from the Theuma and Tippersdorf quarries, laid in

cement mortar. At the springings it is 13·12 ft. deep, and at the key 49·2 ft. deep. The work was started in August, 1903, and completed in the summer of 1905, the total cost being about £29,500, inclusive of about £1000 spent in land purchase. The largest brick arch bridge is the Great Western Railway bridge over the Thames at Maidenhead, with an elliptical arch having a span of 128 ft., and rise of 24 ft. 3 in.

Suspension Bridges. "Next to a common log or beam, the most simple and easy contrivance for establishing a constant communication from bank to bank of a river, or between projecting portions of an intervening gap, is that of a rope or flexible line: indeed, the necessity must have given birth to the idea." (Warr.) In India and South America animal hide and vegetable fibre were the chief materials employed, but in Bhootan, north-east of Hindustan, there is a suspension bridge with iron chains of such antiquity that its origin is lost in fable.

The first iron chain suspension bridge in England was built over the Tees, near Middleton in Yorkshire, about 1741. It was nearly 70 ft. long and only 2 ft. wide, consisting of a footway laid on chains stretched nearly straight. This is probably typical of the earliest forms, the later method being to suspend the footway by vertical bars of different lengths from the curved chains, so that it may be kept level throughout, and the chains being hung with a greater dip are under less tension. The reduction of stress is directly proportional to the increase of dip, except for the extra weight of metal due to the greater length round the curve.



1. A RUSTIC BRIDGE

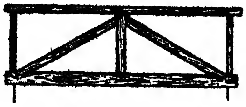
A chain of uniform weight hanging freely takes the shape of a *catenary* curve, while if the weight be distributed uniformly over the horizontal width of span the curve will be that of a *parabola*. In practice the shape is usually that of a *modified catenary*. The great bridge at Freiburg, shown in **12**, was 807 ft. span and 65 ft. deflection. Each of the main suspension cables, 5½ in. in diameter, was composed of 1056 lines of wire 0·12 in. diameter, passed through a boiling mixture of linseed oil, litharge, and soot, to prevent corrosion.

The Menai suspension bridge, 580 ft. span, with a deflection of 43 ft., consists of 16 chains in four groups of 4, dividing the bridge into three lines of way, the central, 4 ft. wide for foot passengers, and the two outer each 12 ft. wide for general traffic. The 16 chains were composed of links or bars of wrought iron in sets of five, 10 ft. long, 3¼ in. broad, and 1 in. thick, with a hole 3 in. in diameter bored in each end for the connecting pins. The entire cross-section, therefore, consisted of $5 \times 16 = 80$ bars, with a total sectional area of $80 \times 3\frac{1}{4} \times 1 = 260$ sq. in.

The Hungerford suspension bridge, first erected over the Thames and now placed over the Severn at Clifton, is 702 ft. span with 50 ft. deflection. In its present position it has a very fine appearance, owing to the height of the banks upon which the towers are placed, and although the rise of the tide reaches to 36 ft., there is ample headway for ships to pass under without lowering their masts. The Saltash bridge over the Tamar, near Plymouth, is a unique structure designed by I. K. Brunel. It consists of two spans, each formed of an elliptical iron tube, arched upwards and braced by wrought-iron rods to chains dipping similarly to those of a suspension bridge. It is, in fact, a suspension bridge with the pull of the chains resisted by the overhead arched tube instead of by anchor blocks buried in the ground on either side.

Iron Girder Bridges. The earliest iron bridges naturally took the form of simple beams, but the limit of strength for this form was soon reached. The experiments of Fairbairn and Hodgkinson showed that hollow beams could be built over much greater spans; and, following up the principles they discovered, they constructed the Conway and Britannia tubular bridges, like a long, rectangular tube with flat sides and cellular top and bottom, the Britannia bridge over the Menai Straits being shown diagrammatically in section by **13** and in pictorial elevation by **14**, where the greatest span is 460 ft. in the clear. Bridges of this type, although based upon sound principles, did not meet with much favour, owing to certain drawbacks involved. They are in effect iron tunnels, are difficult to protect from corrosion inside on account of the steam from the locomotive engines, and outside from the sea air. They also present a continuous surface of great area to the force of the wind, and the positions where bridges of such span are required are usually very exposed. The improvements introduced in the construction of modern bridges will be dealt with subsequently.

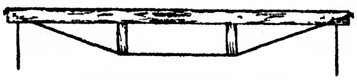
Cast-Iron Bridges. About the same time Telford was constructing cast-iron bridges, of which Southwark Bridge over the Thames, now being rebuilt, at London, was the finest example. It was the largest cast-iron bridge, the middle arch having a span of 240 ft. with a rise of 23½ ft. The two side arches were 210 ft. span and 18 ft. 10 in. rise. The arches themselves consisted of eight ribs with webs 2½ in. thick and flanges 4½ in. thick; these were 6 ft. deep at the crown and 8 ft. at the springing, in 15 divisions attached by means of dovetailed sockets and wedges. The spandrils, or spaces between the arch and roadway, were filled up with cast-iron framing of diagonal struts, bearing cast-iron plates, upon



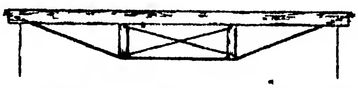
2 Timber foot bridge

3 Truss for foot bridge

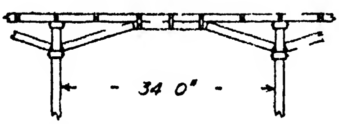
4 Timber road bridge



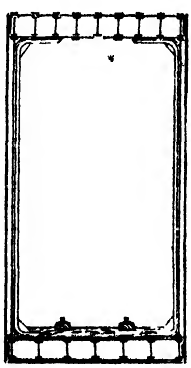
5 Truss for road bridge



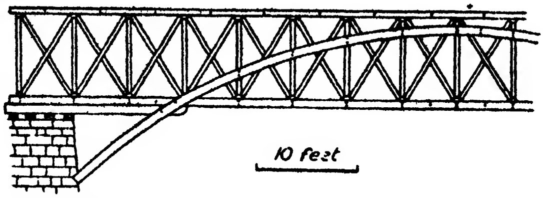
6 Braced truss for road bridge



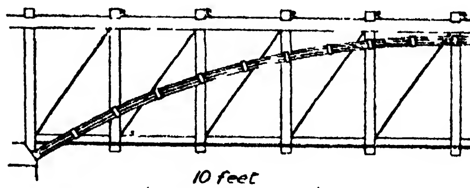
7 Glasgow bridge built 1832



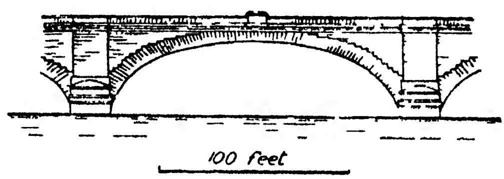
13 Section of
Britannia Tubular Bridge



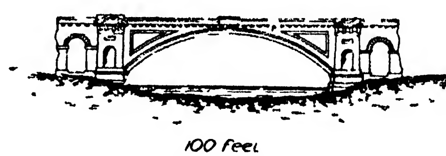
8 Arched truss bridge on Reading Railroad, U S A



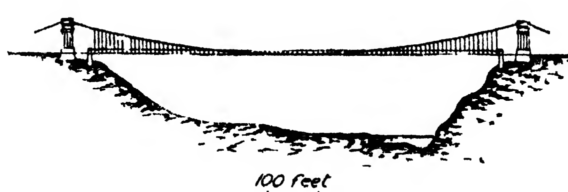
9 Arched truss bridge
on Pennsylvania Railroad, U S A



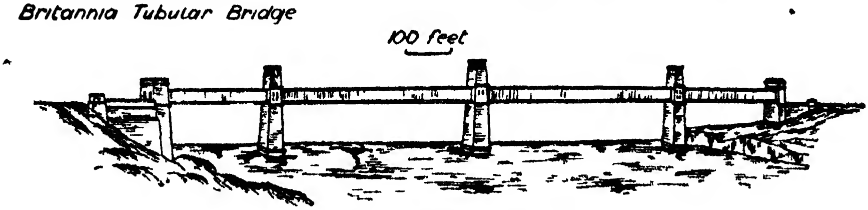
10 London Bridge



11 Chester Bridge



12 Freiburg Suspension Bridge.



14. General view of Britannia Tubular Bridge

2-14. BRIDGES AND BRIDGE CONSTRUCTION

which the roadway lay. Other bridges of the same type were built at Tewkesbury and elsewhere. One of the most pleasing was built at Craigellachie, over the Spey in Inverness-shire, with a span of 150 ft. and a rise of 20 ft. It may be noted that cast-iron bridges were based upon the principle of the arch, thus utilising the extraordinary compressive strength of the material.

Bridge Foundations. The engineers of the rising generation having the use of ferro-concrete and steel piling will probably marvel at the temerity of bridge engineers in building upon wooden piles and platforms so late as the nineteenth century, but it has yet to be proved that the newer materials have any advantage. The piles under old London Bridge remained sufficiently sound to support the massive superstructure after nearly 700 years, and the present London Bridge, built in 1828, rests upon a plank and pile foundation. Trajan's bridge across the Danube rested on wooden piles, and one of these, when taken up for inspection after having been in use more than 16 centuries, was found to be petrified to a depth of three-fourths of an inch, but otherwise little altered. Cast-iron piles have been in use since about 1820, but they appear to have been used only for cofferdams and wharf walls.

Rolled-steel Piles. Rolled-steel piles of a pattern practically identical with some of the cast-iron piles of nearly a century ago have been recently introduced. They are particularly suitable for sheeting round foundations, cofferdams [**15**], and bridge cylinders [**16**]. When put together the joints run at 12 in. centre to centre, and the shape permits of any outline in plan being followed. For a sudden bend the pile is curved transversely, as **17**.

Screw Piles. Small bridges and pier jetties are often carried by screw piles. **18** shows the screw for the lighter cases and **19** for the heavier. The former may be made in a separate casting attached to a wrought-iron or steel column, or may be simply formed on the lowest length of a cast-iron column. The latter is always formed on the bottom length of a cast-iron column, and is usually adopted for column diameters of 12 in. to 30 in. They are screwed in by a temporary timber framing bolted on to the upper flange and rotated like a capstan head by a rope from a crab winch. The width of the screw blade varies according to the nature of the foundation; the largest diameters are used upon sand and peat.

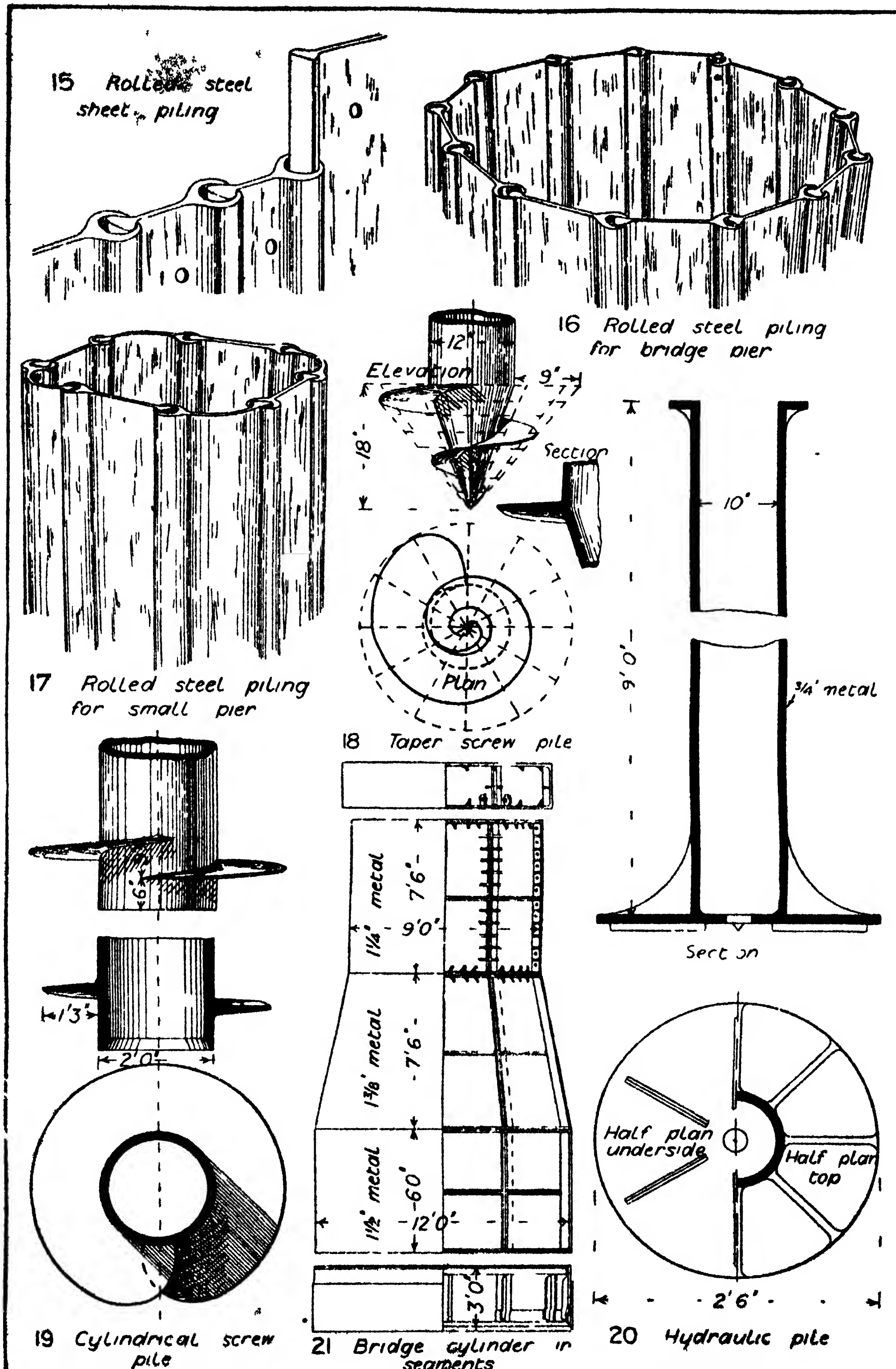
Hydraulic Piles. For similar purposes, hydraulic piles are sometimes used upon a sandy foundation. A railway viaduct was carried across the sands of Morecambe Bay in spans of 30 ft., each pier being composed of two main piles and two raking piles, as **20**. The piles were in 9 ft. lengths, and 10 in. diameter outside, with $\frac{3}{4}$ in. thickness of metal. The discs on the main piles were 30 in. diameter, with an orifice 2 in. diameter for the discharge of water. The mode of sinking consisted of loading the top of each pile and guiding it by a pile engine, pumping water down the pile, and as it escaped through the bottom working the pile backwards and forwards with an alternating rotary motion, so that the cutters on the disc could loosen the marl while the water washed away the sand and fragments. The piles were sunk to an average depth of about 20 ft., and it was calculated that the sand had a supporting power of about 5 tons per square foot when it had settled.

Bridge Cylinders. The foundations for heavy bridges may be of masonry built up within cofferdams or caissons, or may be of cast-iron cylinders filled with concrete. This arrangement is shown in **21**. Timber piles are driven at intervals round the site to act as guides to the cylinders, the bottom section, consisting of a steel curb with cutting edges, is put in position, and the cast-iron segments forming the body of the cylinder are then bolted together on the curb with water-tight joints. The cylinder soon begins to sink by its own weight, and the material is then excavated from the interior by hand or by grabs, and additional sections are bolted on at the top. Extra weight is added when necessary to force the cylinder down. Two or more such cylinders are strongly braced together at the top to form a single pier.

The Cantilever Principle. The greatest advance in modern bridge building for large spans has been due to the advantage taken of the cantilever principle. When a beam is continuous over several spans it is found that between the supports there are two points where the bending moment vanishes; these are the *points of contrary flexure*, or where the tensile stress in the upper portion and compressive stress in the lower portion, above each support, diminish to zero preparatory to their gradual increase to the maximum stresses of the reverse character at the centre of the span. This is the principle of cantilever bridges.

It is the same as if cantilevers were built out on both sides of the pier to balance each other, and the cantilevers from adjoining piers then carried an ordinary girder suspended between their points, these points being equivalent to the points of contrary flexure in a continuous beam.

The Forth Bridge. This bridge [**22**], based upon the cantilever principle, involved nothing theoretically new, but the magnitude of the structure and the marvellous skill shown in the design evoked well deserved praise; and although many subsequent bridges of the same kind may reach a larger span, the chief merit still remains with Sir Benjamin Baker and those allied with him in the work of having been the successful pioneers. The work of erection, although expedited with all the skill and force that modern science could suggest or money could procure, occupied no less than seven years. Altogether it reaches from 90 ft. below high water to 360 ft. above, and is $1\frac{1}{2}$ miles long. The weight of the superstructure is about 45,000 tons, but altogether over 50,000 tons of steel were employed, besides 140,000 cubic yards of masonry and concrete. There is a clear headway for ships of 150 ft. above high water for a width of 500 ft. at each of the two great openings of 1,710 ft. span, or nearly one-third of a mile. Half the bridge only is shown in **22**.



15-21. FOUNDATIONS FOR BRIDGES

The Quebec Bridge. The first bridge designed to cross the River St. Lawrence at Quebec was of the same type as the Forth Bridge, but with 90 ft. more span, making it the largest single span in the world, as indicated in the half elevation [23]. Owing, however, to the inefficient design of some of the struts and to too low a factor of safety a total collapse of the bridge, so far as it was then erected, occurred on August 30th, 1907.

Steps were taken in 1911 to build another bridge, of rather less span and modified in details, but it is not yet erected.

Material for Large Bridges. In large bridges by far the most serious load is the weight of the structure itself; therefore the strongest material compared with its weight is used. If aluminium would bear comparison with steel in strength, its lightness would render it the material without equal for bridges, but at present mild steel holds the premier position. There is practically a limiting span for any material, according to its strength and weight, beyond which it is impossible to go, and we may consider that this was nearly reached in the case of the Quebec bridge.

The Sukkur Bridge. The Sukkur Bridge over the River Indus is upon somewhat the same principle as the Forth Bridge, but decidedly less pleasing in appearance, due to the contrast between the braced compression members and the other parts, as shown in elevation in **24**. These three illustrations show some of the variations of which the cantilever principle is capable.

The Zambesi River Bridge. The bridge over the Zambesi at the Victoria Falls, Rhodesia, completed and opened in 1905, is a two-hinged braced and riveted arch span of 500 ft., with lattice girder spans of 75 ft. for the approaches. It weighs 1650 tons. The arch trusses have a rise of 90 ft., a depth of 105 ft. at the skewbacks, and 15 ft. at the crown. This bridge is remarkable from its position, being built across a rocky gorge about 650 ft. wide, with precipitous cliffs of hard basalt on each side. The front elevation and section are shown in **25** and **26**.

The Grünenthal Bridge. Steel-braced arch bridges have been erected of many different designs; there would, in fact, seem to be almost unlimited scope for variation. The Grünenthal Bridge over the Baltic Canal [27] consists of a single span of 513 ft. 6 in., with an arched girder of bold proportions having a rise of 78 ft. 6 in. and a straight line of roadway running through it. The effect is very satisfactory.

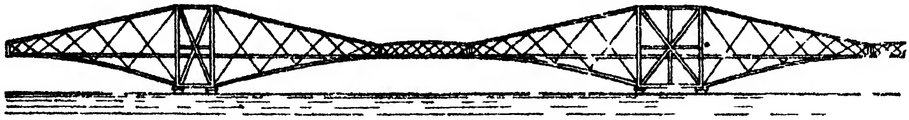
The Garabit Bridge. The Garabit Bridge over the River Truyère in France [28] has a similar arch with pivoted ends, but sunk entirely below the roadway. The span is 541 ft., and the arch has the enormous rise of 196 ft. 9 in. There are theoretical reasons for reducing the braced arch to a mere pin-bearing at the ends, but the effect is hardly agreeable when it is remarked that in all arches the thrust is greatest at the springing.

The Müngsten Bridge. The opposite characteristic is seen in the Müngsten Bridge [29], which is otherwise of a similar character. This bridge is 560 ft. span, and has the enormous proportionate rise of 250 ft. The arch is deepened towards the abutments, where it is framed in with the braced towers supporting the roadway.

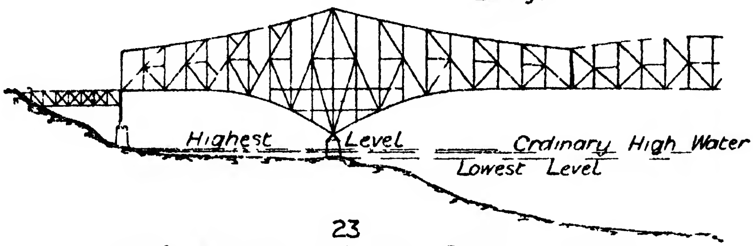
Pipe Arch Bridge. A novel bridge was recently erected over the River Sudbury, near Saxonville, Massachusetts. It forms part of the aqueduct that carries the Boston water supply, and consists of a steel arched pipe [30] 7 ft. 6 in. diameter, and ⅝ in. thick, double riveted. The span is 80 ft. and the rise 5 ft. 6 in. To resist the great thrust on the abutments, about 40 ft. of solid concrete was filled in behind them. Some difficulty was experienced in handling this work, both in the shops and in the field, owing to its unusual character, but it would be impossible to imagine a simpler solution.

Long Span Bridges of the Future. So far back as 1867 Sir Benjamin Baker, in a book entitled "Long Span Railway Bridges," showed that of eleven different types of bridge, which included every class of design not absolutely eccentric, that which he called the *continuous girder of varying economic depth* was the one capable of being built to the greatest span. This type was practically identical with that afterwards adopted for the Forth Bridge. By mathematical investigation he showed that the limiting span was theoretically 2500 ft. in wrought iron, at which span, with an infinite quantity of material and a strain of 80 cwt. per square inch, the bridge could not carry more than its own weight. With steel having a value of 130 cwt. per square inch compared with 80 cwt. for wrought iron, he showed that the limiting span would be 4000 ft. The practical limit would, however, be reached at about half these spans, owing to the excessive cost due to the great weight of material involved in the wider spans. We can hardly anticipate the introduction of any new principles of design, but we may hope that improvements in steel will enable higher strains to be safely reached, and the saving in weight that this will effect will enable still wider spans to be crossed.

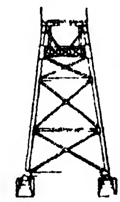
The New Southwark Bridge. This is to be a five-span steel bridge, with a centre span of 140 ft. 6 in., intermediate spans of 131 ft., and shore spans of 123 ft. The new bridge will be 55 ft. wide, as compared with a width of 42 ft. 6 in. for the old bridge. Attention has been given to the improvement of the gradients both on the approaches and on the bridge itself, and there will be no slope greater than 1 in 32. The total length of the new bridge will be 703 ft. The sites for the piers will be quite different from those of the old bridge. The usual method of sinking foundation caissons to the depth required for the piers will be employed, the material for the piers being British granite. The designs are by Messrs. Mott and Hay as consulting engineers, and Sir Ernest George as consulting architect, and the total cost is estimated at about £280,000.



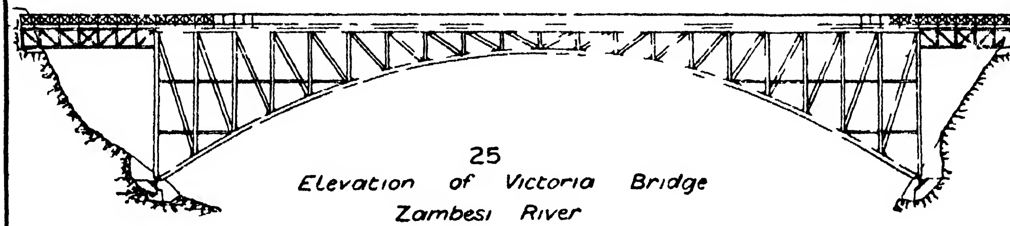
22 Elevation of one span of the Forth Bridge



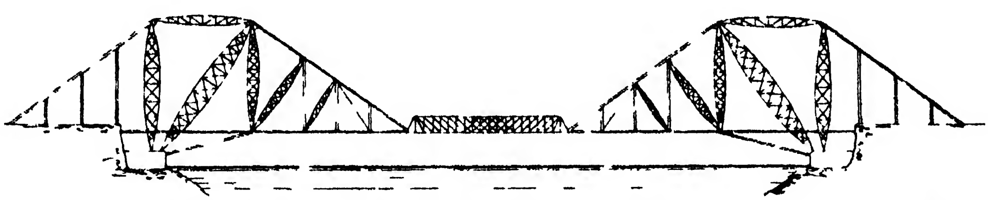
23 Half elevation of the Quebec Bridge



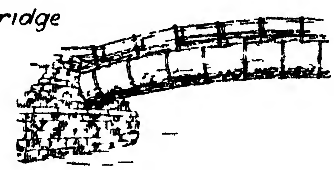
26 Section of 25



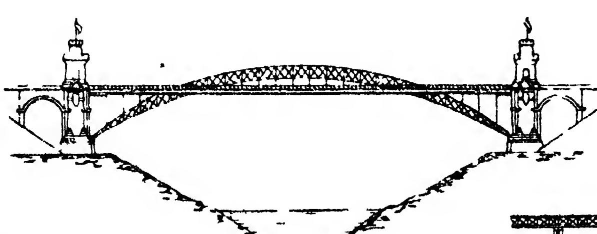
25 Elevation of Victoria Bridge Zambesi River



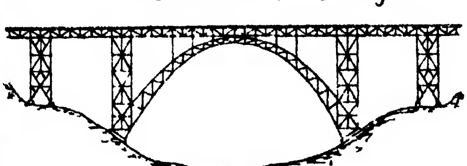
24 Elevation of the Sukkur Bridge



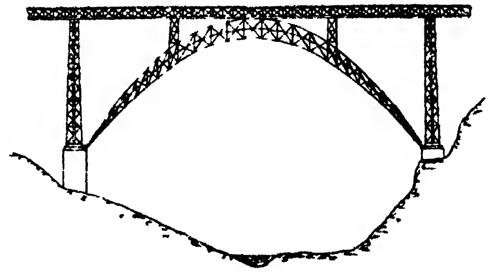
30 Part view of Pipe-Arch Bridge



27 Elevation of the Grunenthal Bridge



29 Elevation of the Mungsten Bridge



28 Elevation of the Garabit Bridge

22–30. MODERN LARGE SPAN BRIDGES

The first proceeding before beginning the removal of the old bridge was to provide temporary footways 8 ft. 4 in. wide on both sides of the structure. To carry these footways it was necessary to arrange independent foundations, as the old piers are to be removed. These foundations, which consist of timber piling, were driven into the river so as to be clear of existing piers on each side, and are designed not only with due consideration of the large passenger traffic over the bridge, but also to carry the weight of the overhead cranes, staging, and cross-girders, which had to be installed for the purposes of the work. The contractors, Messrs. Sir William Arrol & Co., installed three travelling cranes of ten tons capacity and 84 ft. gauge on the temporary bridges, which were also used to carry the hydraulic, electric, telephone, and other mains temporarily diverted during the process of rebuilding.

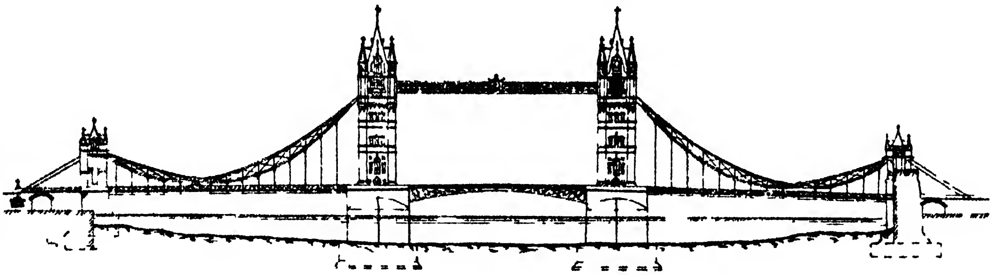
Need for Opening Bridges. When a navigable waterway passes between steep banks, it is possible to build a fixed bridge high enough for vessels to pass under without lowering their masts, as in several of the cases of large span bridges that have already been mentioned; but there are many more cases where the bridge has to be fixed at so low a level that some portion of it must be made to open, although it is possible to build steamships of 2000 tons burthen to pass through the small and low arches of an ordinary river bridge. For example, several screw colliers were built to pass up the Thames through the small arches of the old Vauxhall Bridge, where the clearance remaining all round was only measured by inches. An interesting example occurs at Newcastle-on-Tyne, where a noted high-level road bridge crosses between the banks with a railway track above it, and close alongside a low-level bridge connects the lower parts of Gateshead and Newcastle. When the Elswick Works, founded by Lord Armstrong, began to furnish the large ironclads with their powerful armament, it was found that the old low-level fixed bridge prevented the battleships from passing up the Tyne to the Elswick Works to receive their complement of big guns, and a new low-level bridge was erected in 1876, with an opening span, in the form of a swing bridge giving two passages each of 110 ft. clear width, and, when closed, forming a roadway 50 ft. wide from shore to shore.

The Tower Bridge, London. There are several types of movable bridges, the oldest of which is the so-called drawbridge spanning the castle moat of feudal times. This was a planked roadway lifted by chains attached to the outer end, and working on a horizontal shaft near the portcullis of the entrance to the castle. This would now be called a *bascule* bridge, and was the progenitor of various modifications of which the Tower Bridge, over the Thames at London, is the most prominent example. The Tower Bridge [31] is a combination of a bascule bridge with two suspension bridges. It consists of a central span of 200 ft., in two half spans, lifting on axles at the base of the towers, the movement of each being effected by a pinion, rotated by a steam engine and working into a quadrant rack attached to the pier end of each leaf. The towers are tied together at the top by a straight footway, and they support on the shore sides two suspended spans of 270 ft. each. The "chains" are, in this case, really braced girders made with a suitable curve in two portions. The towers are essentially steel-framed structures clothed with stonework, for architectural effect. The total height of the towers, measured from the level of the foundations, is 293 ft. For the construction of the bridge, about 235,000 cub. ft. of granite and other stone, 20,000 tons of cement, 70,000 cub. yd. of concrete, 31,000,000 bricks, and 14,000 tons of iron and steel were used.

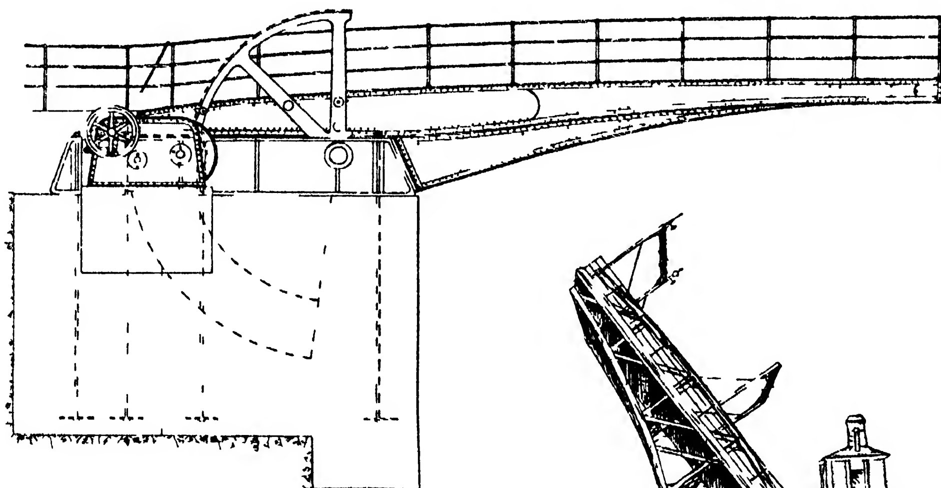
Bascule Bridges. The essential feature of the bascule bridge is the turning upon a horizontal axis as above described, the lifting being seldom effected by chains. Smaller bridges on the same principle have been erected at the Bristol Docks, at Deptford Creek, and elsewhere. One great difficulty bascule bridges have to contend with is the wind, which, while tending to prevent one leaf from being opened, may expedite the opening of the other side to a dangerous degree, unless provision has been made to counteract it. In the case of the Tower Bridge, a wind pressure of 56 lb. per sq. ft. was allowed for; and as an average high wind does not reach more than about 22 lb. per sq. ft., there is an ample margin for safety. An illustration of a bascule bridge in leaves of about 60 ft. total span is given in 32. This is worked by manual power.

Rolling Bridges. A modification of the bascule bridge is found in the rolling bridge, such as the Scherzer Rolling Lift Bridge over the Cuyahoga River, Cleveland, Ohio, of 160 ft. span, double track [33]. A sketch of one leaf of a bridge upon the same principle is shown open in 34. In this form, a pure rolling motion is substituted for the axle friction of the earlier bascules, and it also has advantages over the more commonly used swing bridge, which requires a free horizontal space equal to its radius in which to swing.

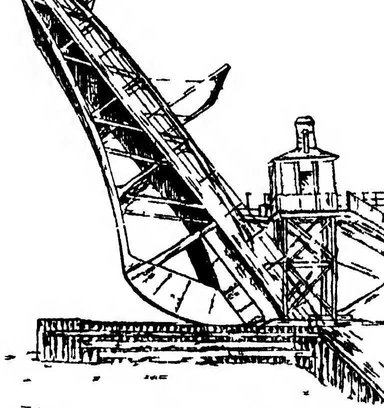
Swing Bridges. A swing bridge is one turning about a vertical axis, and is the usual form of movable bridge over a dock entrance. The earlier swing bridges were worked by hand power, turning upon a central pivot and resting upon rollers after the fashion of a railway turntable. When the dock entrances were increased in width to suit the larger ships that were built, hand power was insufficient to work the swing bridges, and hydraulic power took its place, the weight to be moved increasing to five or six times the original amount. In order to economise the space required for swinging, the tail end was made short and loaded with kentledge, and various ingenious details were adapted to reduce friction and facilitate the working. The centre pivot became a hydraulic press of sufficient power to lift the whole weight of the bridge off the resting blocks, and a rack was bolted to the tail end into which was geared a pinion worked



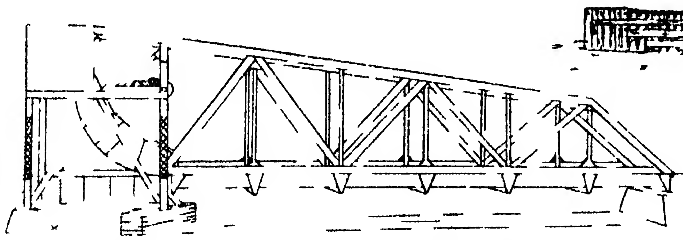
31 Tower Bridge London



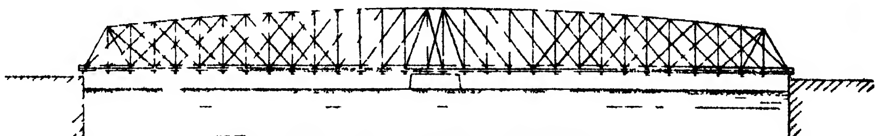
32 Hand power Bascule Bridge



34 Sketch of a Rolling Bridge when open

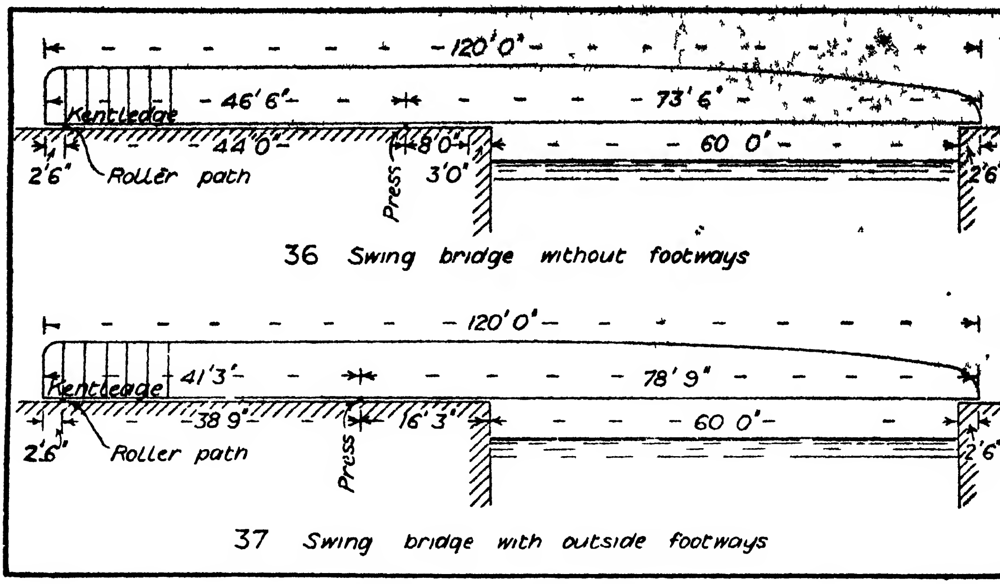


33 Scherzer Rolling Lift Bridge Cleveland Ohio



35 Raritan Swing Bridge New Jersey

31–35. SOME MOVABLE BRIDGES



36 Swing bridge without footways

37 Swing bridge with outside footways

DIAGRAMS OF MOVABLE BRIDGES

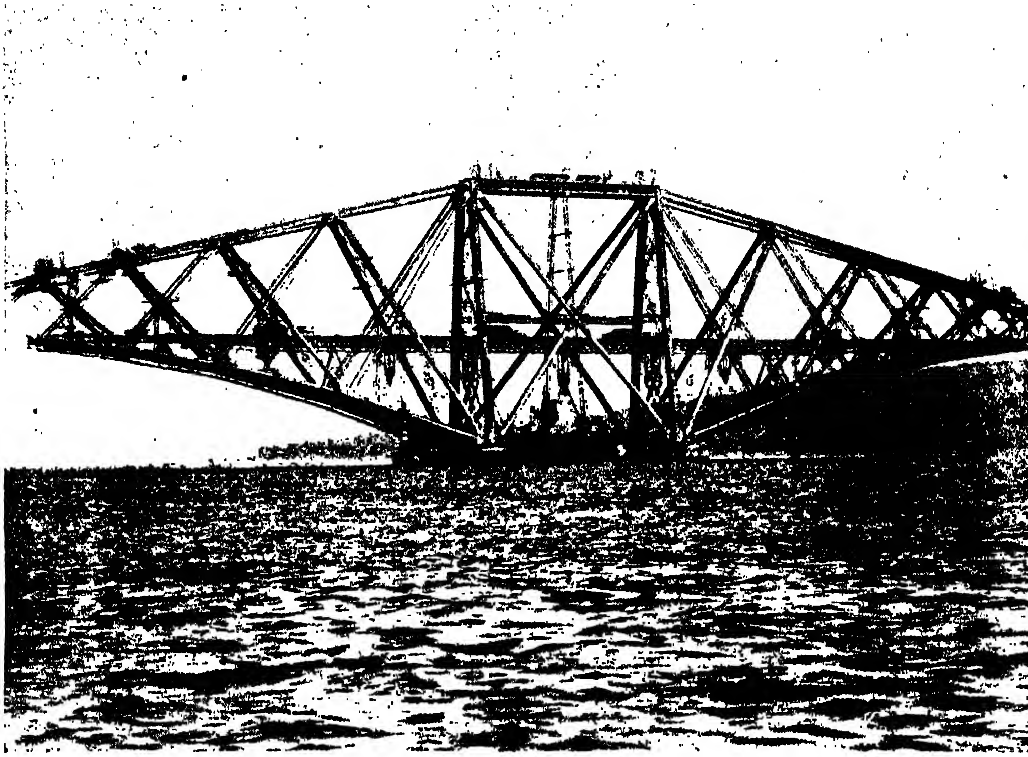
by a hydraulic engine actuated by a pressure of 700 lb per sq in. An inverted roller path was employed in some cases for the tail end rollers to work upon, so that the bridge should have no chance of tilting into the dock while opening or closing. Some of the hand power bridges swing in two leaves, to reduce the weight to be moved by each capstan; but when hydraulic power was used, a single leaf was always adopted. The swing bridge carrying the roadway over the 80 ft entrance of the Millwall Docks, erected under the supervision of the writer as assistant out door manager to Lord Armstrong's firm, had a length of 150 ft and width of 45 ft, and weighed about 500 tons. The largest opening given by a swing bridge appears to be on the Penfeld River, at Brest. The bridge is built in two leaves, each 286 ft long, and spans a clear waterway of 350 ft 6 in. The longest swing bridge is one over the Raritan River, New Jersey [35], being double ended, 472 ft long, swinging on a central pier, and providing an opening on each side of 216 ft clear.

Stresses in Opening Bridges. It should be observed that a remarkable duplication of stresses occurs in all movable bridges. When closed they rest upon end supports so that they are in the condition of an ordinary girder supported at the ends with the upper portion in compression and the lower in tension. When, however, the bridge is opened, whether it is a bascule, or swing bridge or the modern form of drawbridge, it is in the condition of a cantilever and the stresses are reversed. This reversal of stress necessitates a higher factor of safety being allowed, or, what is the same thing, a smaller working intensity of stress, and such bridges are therefore comparatively heavier than fixed bridges of the same span.

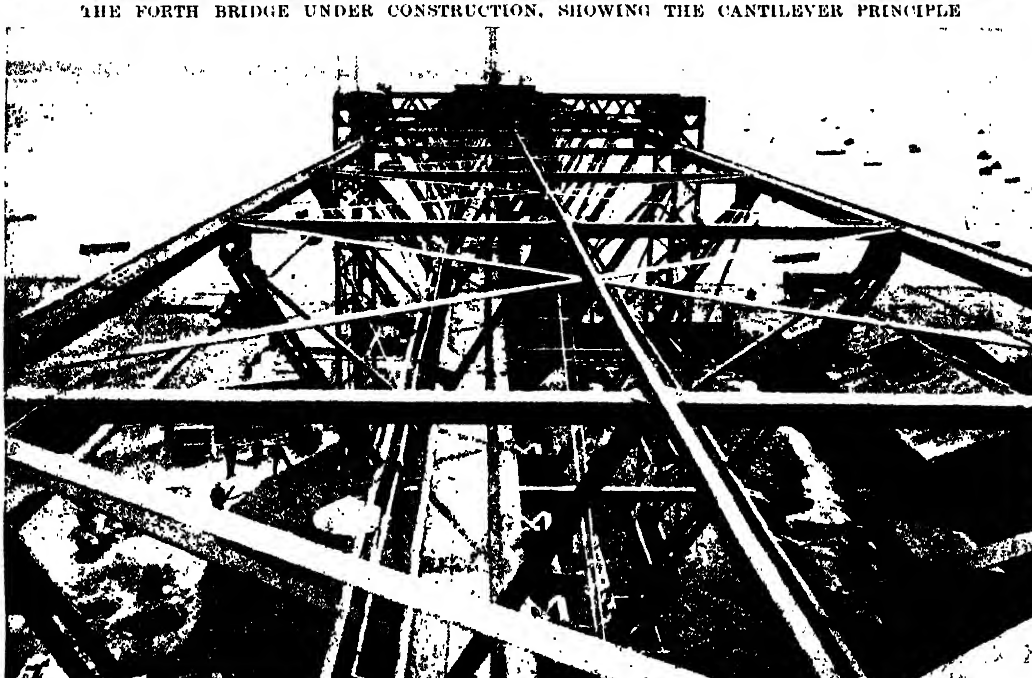
Assuming the bridge to be required to span the 60 ft. or 80 ft entrance lock of a dock basin, the total length of the bridge will average twice the width of entrance, but this depends partly upon the width of the bridge and whether a passage or gangway must be left outside the bridge when open, for warping the ships in and out of the dock. The centre pivot would be on a hydraulic lifting press, the position being found thus, bearing at nose end 2 ft 6 in + width of entrance + gangway (if any) + half width of bridge = distance from point of bridge to centre of press. The radius to centre of tail roller path = centre of press to tail end − 2 ft 6 in; the tail end must not be less than half the length of nose end as an extreme difference. The outline of a bridge for a 60 ft lock, having a roadway only and being 16 ft wide over all, to leave a 3 ft gangway when open is shown in 36, and a similar bridge with a footway on each side making a width of 32 ft 6 in over all, and not requiring a gang way left, is shown in 37.

Drawbridges. Modern drawbridges, or traversing bridges, are pulled back horizontally by powerful machinery placed in a pit below the road level to leave an open waterway; such a bridge was erected under the writer's supervision at the Millwall Docks, London over the entrance to the inner dock. In place of the central pivot of a swing bridge to lift it off the blocks, there is a hydraulic cylinder near the edge of the dock under each main girder, and horizontal hydraulic cylinders and rams with chains and multiplying sheaves to haul the bridge backwards and forwards. To guide the bridge to its exact position in closing, a projecting horn was fixed underneath the nose of the bridge, which entered a groove with a sloping bottom on the further coping, and a very curious phenomenon occurred in connection with this soon after the bridge was completed. Upon attempting to close the bridge one afternoon it was found that the horn was

THE STEEL NETWORK OF MODERN BRIDGES



THE FORTH BRIDGE UNDER CONSTRUCTION, SHOWING THE CANTILEVER PRINCIPLE

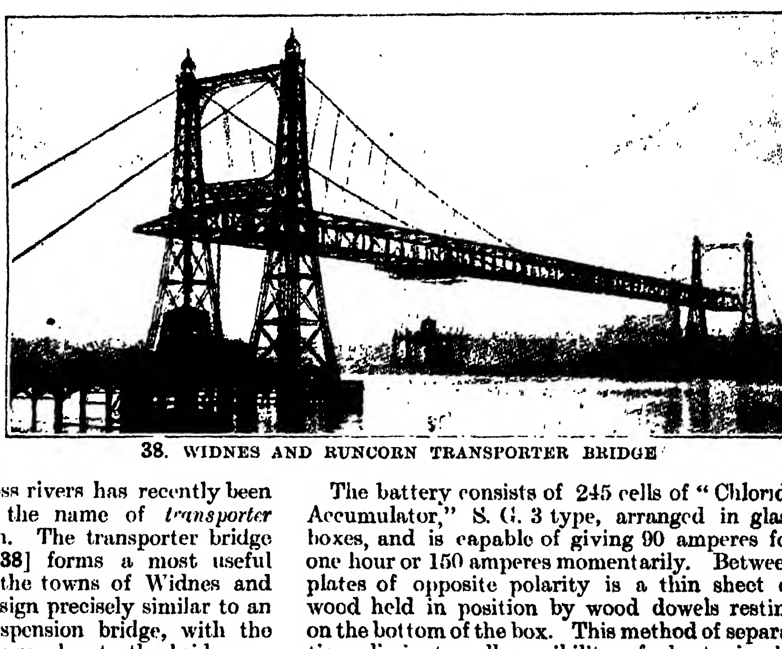


THE TRANSPORTER BRIDGE AT POOLE HARBOUR UNDER CONSTRUCTION

too low to enter the groove, and a long time elapsed before the closing could be effected. The next time the bridge was used it entered all right, but again on one occasion it was too low. The engineer in charge considered the matter and came to the conclusion that the sun acting upon the dark painted bridge had caused a greater expansion in the top flanges of the girders than in the bottom flanges, and this had bowed the bridge downwards; he therefore had the bridge painted white, and the trouble immediately disappeared.

Lifting Bridges. Bascule bridges are sometimes called *lift bridges*, but the term properly belongs to those lifted bodily, of which, however, there are not many, and they are all of small span. There is one on the Grand Surrey Canal, in South London, which is lifted by hand-power gearing to allow barges to pass under.

Pontoon Bridges. Another form of bridge is the military pontoon system, and its allied type, the bridge of boats. These are only of a temporary nature, and hardly within the scope of this article, but they deserve to be mentioned as there is a large permanent bridge based upon the floating pontoon principle over the River Hooghly at Calcutta. Another form of pontoon is the caisson, either rectangular or boat-shape, used to close the mouth of a graving dock, or dry dock. It is floated into position, and then water is admitted to the interior to sink it; the pressure of the water in the outer dock when the graving dock is pumped dry keeps it in position. When it is desired to remove the caisson, water is admitted to the graving dock through the sluices; the water in the caisson is then pumped out, allowing it to float so that it can be removed.



38. WIDNES AND RUNCORN TRANSPORTER BRIDGE

Transporter Bridges. A new system of transit across rivers has recently been developed to which the name of *transporter bridges* has been given. The transporter bridge across the Mersey [38] forms a most useful connection between the towns of Widnes and Runcorn. It is in design precisely similar to an ordinary stiffened suspension bridge, with the exception that the approaches to the bridge are at a low level—thus dispensing with the very costly high level approaches—and the traffic, both foot and wheel, is carried over in a car suspended to the under side of the bridge, and is worked electrically. The transporter car consists of a platform 55 ft. long by 54 ft. wide, and is suspended from the trolley by steel wire ropes, hung so that they prevent both side and end oscillation of the car. It is capable of holding at one time four two-horse farmers' waggons loaded and 300 passengers, the latter being protected from the weather by a glazed shelter with folding doors at the end and side. On the top of the car is fixed the operator's cabin, in which is placed the switchboard, so that the operator has a full view of the course and has the car quite at his command. The time occupied by the car in crossing is about $2\frac{1}{2}$ minutes; so, allowing the time for loading and unloading, it is capable of making about nine or ten trips per hour. The bottom of the car is about 12 ft. above high-water level, and clears the Ship Canal wall by about 4 ft. 6 in. The transporter is carried from the lower flanges of the stiffening girders, on which are fixed the rails upon which runs the trolley, from which is suspended the car. The trolley is about 77 ft. long, and is carried by 16 wheels on each rail. It is propelled by two electric motors of about 35 B.H.P. each, a large excess of propelling power being provided, partly for economy of working and principally to be ready for any emergency of strong head winds with heavy load. The motors are fixed to a kind of bogie arrangement in the trolley, so that in the case of large curvature of the bottom boom of the stiffening girders, due to either temperature or load, the driving wheels would be certain to bear hard on the rails.

The battery consists of 245 cells of "Chloride Accumulator," S. G. 3 type, arranged in glass boxes, and is capable of giving 90 amperes for one hour or 150 amperes momentarily. Between plates of opposite polarity is a thin sheet of wood held in position by wood dowels resting on the bottom of the box. This method of separation eliminates all possibility of short circuits between the plates and reduces to a minimum the amount of attention required by the cells.

Mr. J. J. Webster, of Westminster, and Mr. J. T. Wood, of Liverpool, were the consulting engineers for the whole work, the electrical equipment being carried out by Messrs. Mather and Platt, of Manchester.

HENRY ADAMS.

"The Renascence of Wonder." A Survey of some of the Principal Essayists, Critics, Historians, and Philosophers.

NINETEENTH CENTURY PROSE

Nineteenth century prose, infinite in its complex variety of style, is distinguished by the common characteristic of critical inquiry: it aims at truth; it strives to touch the very heart of life. There are, as Goethe said, many echoes, but few voices. This is largely true of all literary periods; but the voices of the nineteenth century will compare advantageously with those of any preceding period. Where prose is concerned they are heard at their best, perhaps, in the novel. But the "new note" is hardly less resonant in the essay, the biography, the history, the book of theology, the narrative of travel, the scientific treatise, the studies of philosophy, art, education, and economics.

A Great Period in Letters. If the twentieth century has opened for us with a wider and a nobler outlook on "the things that matter," it is due largely to the work accomplished in the preceding century in the domain of English letters, when our great writers took to heart the aphorism of an eighteenth-century poet. They saw with Pope, but with a finer insight than his, that "the proper study of mankind is man." The literature of knowledge and the literature of power belonging to this period are alike marked by a dominating but informed interrogative; for it was not only in imaginative writing that the last century witnessed what Mr. Watts-Dunton has called "the Renascence of Wonder," but in all fields of literature—in criticism and science, not less than in poetry and romance, this rebirth of "wonder" took place. The originator of the phrase thus explains it: "The Renascence of Wonder merely indicates that there are two great impulses governing man, and probably not man only, but the entire world of conscious life: the impulse of acceptance—the impulse to take unchallenged and for granted all the phenomena of the outer world as they are—and the impulse to confront these phenomena with eyes of inquiry and wonder."

"The Renascence of Wonder." Before studying the effects let us glance at the causes of this change in the nation's literary life. The French Revolution shattered the scholastic formalism of English letters. Jean Jacques Rousseau stirred up a feeling for humanity such as England had never before acquired from French or Italian writers, much as she had been influenced previously by Continental models. The effects of the Red Terror threw the thoughtful back for a time into the slough of despond. We have seen how Wordsworth, for example, was bowed down in this way. Then a Scottish teacher read Mme. de Staël's "De l'Allemagne," set himself to master the German language, put Jean Paul Richter in the place of Jean Jacques Rousseau, and by the exercise, on the one hand, of the extraordinary knowledge he acquired of German philosophy and German individualism, and his painstaking elucidation of the Cromwellian epoch on the other, set aloft an ideal of manhood and patriotic duty which, faulty in many respects as the design may have been, influenced materially the popular view of history and the outlook on nature. There were others, besides Carlyle, who drank deeply at the Teutonic spring. Wordsworth was one, Coleridge another. Byron a third; Scott and De Quincey were of the company. Each was affected differently, but at the same time profoundly. A new spirit was introduced into our literature—the spirit of wonder, which is of all human characteristics the most natural, the most fruitful in its influence not merely upon literature and the other arts, but upon every work of the hands of man.

Thus romance was reborn; metaphysics acquired a new meaning; humour was reincarnated. Men longed to look at things as they were—to see them "whole," and of all the master-minds of the century, Carlyle is the one who, both directly and indirectly, has stirred most deeply the heart of the vast reading public called into being by the mechanical inventions of what the late Dr. Russel Wallace called "the Wonderful Century."

Literature and Politics. The history of the essay, both critical and constructive, in the century we are considering, is bound up with the history of the periodical.

Something of the same kind may be said of both poetry and the novel. The various periodicals having a political bias, if not basis, literature developed more or less under the ægis of politics. The writers made the reviews and the reviews helped to make the writers. If the student, happily versed in more modern literature, approaches some of these old masterpieces in a spirit of wonderment at the fame attached to them, he must try to forget his later knowledge. He must look at the work with the eyes of the generation upon which it was sprung with such magnetic effect. Today much of the vital force which animated the work of earlier writers has been scattered, much of their "thunder" has been stolen, the knowledge in the light of which they wrote has been found to be misleading. But the saving salt of an individual style preserves many an old and obsolete book from the blight of oblivion.

Styles of the Great Writers. Among the influences on later prose must be remembered the prose of the poets—the prefaces of Wordsworth, the miscellanies of Scott, the critical essays of Coleridge, the letters of Byron, Shelley, and Keats. But the student has a wonderful

variety of object lessons in style before him, apart from these great names. There are the Puritan fervour and grim humour of Carlyle, the gentle intimacy of Charles Lamb, the graceful confidences of Leigh Hunt, the aerial cadence of De Quincey, the emphatic, unmistakable vigour of Cobbett, the brilliant antitheses of Macaulay, the incisive phrases of Hazlitt, the wit of Sydney Smith, the beautiful imagery of Ruskin, the flowing sea-music of Swinburne, the classic beauty of Landor's dialogues, the perfect serenity and harmony of Newman, the scholarly prose of Matthew Arnold, the undecorated diction of Hallam and Freeman, the picturesque pages of Froude, the jewelled sentences of Walter Pater, and the sparkle of Stevenson. In the main the prose writer who aspires to style must be an artist just as the poet is an artist, but the secret of style is, ultimately, the harmony between the subject and its treatment.

Literary Style. For general purposes style has been considerably influenced by the usage of journalism. The Press is responsible for a marked lessening of the distinction between written and spoken language. There must always be some distinction between the two. The skilled writer must of necessity possess a close acquaintance with the meaning of words; and it is, perhaps, a defective knowledge of the meaning of words which lies at the root of most failures in composition. The speaker, by means of accent, emphasis, look, gesture, personality, can lend significance to a comparatively poor speech. The writer, if he would impress his readers as effectively as the speaker impresses his audience, must find literary equivalents for the methods and circumstances of platform and pulpit. But the aim of the writer who addresses himself to a wide public should be directed to the perfection of a style that shall be distinctive a copied style is but a mask—clear and colloquial, yet avoiding baldness and vulgarity, and from which foreign words, once so plentiful in English prose, shall be notably absent.

Biographers and Historians. While the essayists have done much to increase our knowledge of bygone, and particularly of Elizabethan, literature, as well as to popularise various branches of scientific learning, the biographers have given to the prose of the period some of its greatest intellectual assets. Southey's "Nelson," Lockhart's "Scott," Carlyle's "Cromwell" and "Sterling," Lewes's "Goethe," Froude's "Carlyle," Masson's "Milton," Spedding's "Bacon," Stanley's "Arnold," are classics that for one reason or another are never likely to be superseded. The influence of English historical methods has been world-wide. The nineteenth century historians are worthy successors of Gibbon. They have determined the unity of history, brought the study of evolution and environment to a pitch of scientific accuracy, and made history a fascinating study.

Theology and science, philosophy, politics, economics, art, education, and travel are briefly touched upon in our chronological study of the leading prose writers of the period. There remain, however, before we take up this chronological study, two facts of especial interest that must be noted. One is the high literary value of much of the scientific literature of the time, as disclosed, for example, in the writings of Huxley; the other is the distinction attained by women writers. The latter is a portent that should commend itself to some philosopher of the future.

Essayists and Critics. No serious student of English criticism can afford to neglect the prose writings of SAMUEL TAYLOR COLERIDGE (b. 1772; d. 1834). They are by no means easy to read at the outset, but when the author's point of view has been attained they will prove most stimulating and suggestive. The "Lectures and Notes on Shakespeare" are especially valuable both on account of their great intrinsic value and the effects they had on later estimates of the national poet.

SYDNEY SMITH (b. 1771; d. 1845), FRANCIS LORD JEFFREY (b. 1773; d. 1850), and HENRY PETER LORD BROUGHAM (b 1778; d. 1868) were jointly responsible for the early numbers of the "Edinburgh Review." They were politicians first and men of letters in a secondary sense. Sydney Smith's was a natural wit, but it was always under the control of good taste His style was natural, and he used with unequalled effect against the forces of pretence and pomposity the process of logical inquiry known as the *reductio ad absurdum*. Jeffrey was master of a style the importance of which is derived from the fact that it served as a model to his greatest contributor, Macaulay. Brougham's zeal for popular education was greater than his discretion as a critic.

The Coming of the "Quarterly." WILLIAM GIFFORD (b 1756; d. 1826), the first editor of the "Quarterly Review," was another "man with a bludgeon," whose best services were those he rendered to the Elizabethan dramatists, and especially to the memory of Ben Jonson. Few men whose names are remembered in literature ever wrote more that has been forgotten than did ROBERT SOUTHEY (b. 1774; d 1843) His fertility of production was as amazing as its variety. He was a scholar, and, considered as a stylist alone, claims a high place among his contemporaries. And yet "of what is called style," he said, "not a thought enters my head at any time I only endeavour to write plain English, and put my thoughts in language which everyone can understand."

SIR WALTER SCOTT (b. 1771; d. 1832) wrote almost as incessantly and as variously as Southey, but with much greater success, independently of his greatest work. His essays on chivalry, romance, and the drama, and his letters on demonology and witchcraft, are still eminently readable; and he was a painstaking as well as a capable editor, especially of Swift. JOHN WILSON (b. 1785; d. 1854), the "Christopher North" of "Blackwood's Magazine," is chiefly remembered as the literary parent of De Quincey, as part author of that brilliant series of dialogues "Noctes Ambrosianæ," and author of a work entitled "Lights and Shadows of Scottish Life,"

JOHN GIBSON LOCKHART (b. 1794; d. 1854), Scott's son-in-law, and Wilson's friend and colleague on "Blackwood," who succeeded Gifford as editor of the "Quarterly," gave to journalism much that by right should have been devoted to literature. His masterpiece is the "Life" of Scott, second only to Boswell's "Johnson" as a model biography.

Charles Lamb. One of the greatest, as he is one of the least pretentious, of English prose writers is CHARLES LAMB (b. 1775; d. 1834); but the now world-famous "Essays of Elia" originally issued from the press, at all events in their collected form, upon a cold and irresponsive world. In the history of English prose Lamb stands as much alone as Landor or Sir Thomas Browne. He is master, not of one style, but of as many styles as he possessed moods. He is full of elusive echoes of the old writers whom he loved. His is the art that conceals art, for seemingly he is as frank and as communicative as Montaigne. His character is written in his "Essays"; his autobiography in his Letters. He wrote for magazines—the "London" in particular—but he wrote what he would, and not merely or principally for the pecuniary proceeds of literary work. Herein, undoubtedly, lies part of the secret of his enduring charm. Then, he was a man of many friends.

His life-story is as inspiring as that of Scott. Posterity reverences Lamb almost as a memory of a golden age, as the embodiment of a quality of heart from which it has parted; it looks on him as Lucifer looked on Paradise lost. But Lamb was not only an essayist of unique charm; he was also a critic of rare insight and surprising accuracy. Nothing that he wrote, and little that his life inspired others to write of him, can the student afford to neglect.

William Hazlitt. In WILLIAM HAZLITT (b. 1778; d. 1830) we have a strong contrast to the man who regarded him as "one of the finest and widest spirits breathing." Hazlitt was indebted to Lamb, and acknowledged the indebtedness; but with a critical faculty as keen as that of Lamb, he possessed not a scintilla of "Elia's" human sympathy; hence, whereas the one is loved the other is given the meed of almost frigid praise. Yet Hazlitt's is a name of first importance. "We are mighty fine fellows," said Stevenson, "but we can't write like William Hazlitt." He is the master of the apt and illuminating phrase. The student of Shakespeare owes much to Coleridge's "Lectures," he owes much also to Lamb's "Critical Essays," but he must also study, and study with attention, Hazlitt's "Characters of Shakespeare's Plays"—a work dedicated to Lamb—and the "Lectures on the Dramatic Literature of the Reign of Elizabeth." Of equal note are the "Lectures on the English Comic Writers" and "Lectures on the English Poets." It must be confessed, however, that there is more venom than justice in the personal sketches he called "The Spirit of the Age." But, as a writer says, noting the haunting motto prefixed to the delightful essay "On Sundials," "if one only counts Hazlitt's serene hours, they prove him to have had something far higher than the talent which does what it *can*. He had his share—no one who has tasted the fruit of those serene hours can gainsay it—of the genius that does what it *must*."

Thomas De Quincey. An object of the most contradictory criticisms is THOMAS DE QUINCEY (b. 1785; d. 1859). Sir Henry Craik, in his introduction to the final volume of "English Prose Selections," describes De Quincey's prose as spurious, and as possessing "all the appearances of eloquence except those that are true," while in the same work Mr. R. Brimley Johnson speaks of his vigorous intellectuality, genius, richness of fancy and splendour of style. With Hazlitt and Lamb, De Quincey was a contributor to the "London Magazine," in which his "Confessions of an English Opium Eater" appeared. De Quincey stands sponsor to the modern school of "prose poets." He has much to attract, but is dangerous to follow. He lacks a certain dignity, is normally without what we understand by the word "reverence," and is at times terribly discursive; but we must remember that the bulk of his work was anonymous journalism, and that the writer kept up a weak physique by the use of opium.

The "Confessions," the historical essays, and the "Autobiographic Sketches" should be closely studied. De Quincey has been styled the "Boswell of Essayism," so intimate are his revelations of both himself and his associates. He possessed to an almost amazing degree an instinct for dramatic expression. Whatever men of whom he wrote may have thought of his character drawing, he was well liked personally, and in his later years he proved a good husband and a devoted father. Perhaps Mr. Birrell is right when he declares that De Quincey will always be "above criticism." This great essayist was a rhapsodist, but he was, too, an inquirer, and his influence was against cast-iron formality in English prose.

The Characteristics of Cobbett. WILLIAM COBBETT (b. 1762; d. 1835) started life by scaring crows, but left a name which will be remembered with those of the most famous writers of his time. He may be said to personify the whole art of self-education. By self-denial and perseverance he acquired a vast sum of varied knowledge, and wielded immense influence as a politician and a journalist, inspiring his countrymen with a reasoned love of their native land. Despite extraordinary difficulties, he learnt English and French so well as to be able to write grammars in both languages, and developed a literary style as natural as Defoe's, as vigorous as Swift's, brightened by humour and telling invective, and perhaps as characteristically Saxon as any that could be named. He was a clean-living man, who delighted in the open air, being a born student and lover of Mother Earth. Above all, Cobbett saw clearly, thought clearly, and uttered clearly. His varied career from plough to Parliament will well repay study. The works he left are as diversified as was his life.

Cobbett's "English Grammar" and "French Grammar" are written in the form of letters to his son, and are unsurpassed in the lucidity of their arrangement and their quality of genuine liveliness. The "English Grammar" may be commended as vastly entertaining as well as instructive. His "Weekly Political Register," started in 1802, was continued, apart from one small break, until his death; it was for two years edited from prison, where he was sent for his strictures on flogging in the Army; and for a time from America, whither he fled to avoid further imprisonment. In 1803 he began the "Parliamentary Debates," whence originated our present "Hansard." He wrote a "History of the Reformation," which is still read, though chiefly by Roman Catholics. His "Advice to Young Men" is full of practical common sense for men and women. Its vigour and frankness are as refreshing as the breath of the sea. His best work is to be found in the picturesque accounts of his political tours on horseback, which are familiar as "Cobbett's Rural Rides," and the student in search of a guide to muscular English would do better to read a chapter from this each day than from almost any other prose work. Of his faults, his egotism has perhaps counted too much to his detriment. That it was a reasoned egotism may be seen in a passage from the "Rural Rides," which we quote below.

A Specimen of Cobbett's Style. Cobbett remarks on the beneficial effects of early rising on the traveller, abstinence from wine and spirits, and moderation in eating, and on the fact that, under conditions specified, the riding of twenty miles was not so fatiguing at the end of a tour as the riding of ten miles was at the beginning of it. He goes on to say:

"Some ill-natured fools call this egotism. Why is it egotism? Getting upon a good strong horse, and riding about the country . . . requires neither talents nor virtues of any sort; but health is a very valuable thing; and, when a man has had the experience which I have had, in this instance, it is his duty to state to the world, and to his own countrymen and neighbours in particular, the happy effects of early rising, sobriety, abstinence, and a resolution to be active. It is his duty to do this; and it becomes imperatively his duty when he has seen, in the course of his life, so many men, so many men of excellent hearts and of good talents, rendered prematurely old, cut off ten or twenty years before their time, by a want of that early rising, sobriety, abstinence, and activity, from which he himself has derived so much benefit, and such inexpressible pleasure. . . . It is seldom that rain, come when it would, has prevented me from performing the day's journey that I had laid out beforehand. And this is a very good rule: stick to your intention, whether it be attended by inconveniences or not: look upon yourself as bound to do it."

Here we have Cobbett the man; no dreamy theorist, but a master of hard facts who is compelled to convey his knowledge in a manner which none can misunderstand. Cobbett is not a great literary character; but his style is the best of models for all who aspire to write clearly and correctly.

Anecdotes and the Minor Morals. ISAAC D'ISRAELI (b. 1766; d. 1848), the father of Lord Beaconsfield, wrote a number of anecdotal works which, though somewhat slipshod, offer evidence of much culture and wide reading, being chiefly notable for the entertainment they afford and the stimulus they give to further inquiry in the by-paths of literary history. The "Curiosities of Literature" is the best of these; its companions are "Calamities and Quarrels of Authors," "Amenities of Literature," and "The Literary Character." JOHN FOSTER (b. 1770; d. 1843), a Baptist minister, was the author of a series of "Essays." That "On Decision of Character" should be read with Cobbett's "Advice to Young Men"; the "Self-Culture" of JOHN STUART BLACKIE (b. 1809; d. 1895); and the "Self-Help" of SAMUEL SMILES (b. 1812; d. 1904).

Landor's "Imaginary Conversations." WALTER SAVAGE LANDOR (b. 1775; d. 1864) was an author who, as Mr. Birrell says, "preferred stately magnificence to chatty familiarity." He lived, in a sense, alone, and his work is also independent. His "Imaginary Conversations" possess strong dramatic qualities which have caused many to wonder that their author failed to write a great play. The "Conversations" were published between 1824 and 1853; they range over a vast area of topics, and are 125 in number. In these lofty and earnest pages we are, says the "Edinburgh Review" of 1846, by turns, "in the high and goodly company of wits and men of letters; of churchmen, lawyers, and statesmen; of party-men, soldiers, and kings; of the most tender, delicate, and noble women; and of figures that seem this instant to have left for us the Agora [Greek equivalent of the Roman Forum] or the schools of Athens, the Forum, or the Senate of Rome. At one moment we have politicians discussing the deepest questions of state; at another, philosophers still more largely philosophising; poets talking of poetry; men of the world of worldly matters; Italians and French of their respective literatures and manners." Landor, in fine, is our English Lucian: the classic writer of dialogues who flourished in Greece during the second century.

Among Landor's dialogues especially admired for their dramatic intensity are those between Peter the Great and Alexis, and Henry VIII. and Anne Boleyn. "I shall dine late," said Landor, in an oft-quoted phrase; "but the dining-room will be well lighted, the guests few and select." Yet we may all some time or other "dine" with Landor as our host and be assured of excellent entertainment. When one is studying the life of Shakespeare, Landor's "Examination of William Shakespeare" may be read as a charming piece of imaginative prose.

Diaries and Collections. WILLIAM HONE (b. 1780; d. 1842) was a sort of minor Cobbett, with something of D'Israeli's feeling for letters. His "Every-Day Book," "Table-

"Book," and "Year-Book" bear tribute to his industrious study of old manners and customs. The first-named contains a tenderly worded dedication to Charles Lamb, and to the "Table-Book" the "gentle Elia" contributed his selections from the Garrick Plays. But Hone's books are chiefly valuable as works of reference to the literary man. The "Papers" of JOHN WILSON CROKER (b. 1780; d. 1857) and THOMAS CREEVEY (b. 1768; d. 1838) supply much intimate detail of the Court, literary, and political life of their time, the one from a Tory, and the other from a Whig point of view. Croker, who is much better known, Creevey having been a "discovery" of Sir Herbert Maxwell in 1903, was a frequent contributor to the "Quarterly Review." His chief work was an edition of Boswell which drew forth a remarkably bitter criticism from Macaulay.

Leigh Hunt. JAMES HENRY LEIGH HUNT (b. 1784; d. 1859) was an essayist of considerable charm and versatility, whose friendships secure for him a greater meed of recognition than his writings, though these are not unimportant. He introduced Shelley and Keats to one another, and brought these poets before the public in the "Examiner," of which he was editor and part proprietor. The student of English literature will find much profit in his "Imagination and Fancy," "Wit and Humour," and "Men, Women, and Books" His "Dante's Divine Comedy: The Book and its Story" is also of value, while his "Autobiography" contains enough to secure for it the permanent interest of all bookmen. London and "The Cockney School" found in him an energetic champion, and his gossipy volume on "The Town: Its Remarkable Characters and Events" retains a certain measure of popularity. As a critic he was appreciative; and his method of handling such themes as old age and child life easily secures for him the affection of sympathetic readers. He had another link with Charles Lamb: he stammered. It was only in part—and that part a small one where his real worth is concerned—that he can be associated with Charles Dickens's satirical portraiture of Harold Skimpole in "Bleak House."

NASSAU WILLIAM SENIOR (b. 1790; d. 1864) was an acute literary critic as well as a political economist. His "Essays on Fiction," articles on Scott, Lytton, Thackeray, and others, contributed to the "Quarterly," "Edinburgh," and other reviews, were published in collected form in 1864, and will well bear perusal by the student. WILLIAM MAGINN (b. 1793; d. 1842), scholar, critic, humorist, was once a great force in the magazine world. He remains, despite all his great gifts, a "might-have-been," the original of the Charlie Shandon in Thackeray's "Pendennis." He was one of "Blackwood's" most brilliant contributors, and as the conductor of "Fraser's Magazine" he gathered round him some of the choicest and most distinguished of contemporary writers. ANNA BROWNELL JAMESON (b. 1794; d. 1860) wrote a volume on "The Characteristics of Shakespeare's Women," which is still a favourite, and her books on art are the classics of the subject.

A Short Study of Carlyle. THOMAS CARLYLE (b. 1795; d. 1881) began his literary career as a writer in the "Edinburgh Encyclopædia," for which, between 1820 and 1823, he wrote articles on Lady Mary Wortley Montagu, Montaigne, Montesquieu, Dr. John Moore, Sir John Moore, Necker, Nelson, Mungo Park, Lord Chatham, William Pitt, and several papers of a topographical character. Only one of these—the paper on Sir John Moore—can be described as inadequate. From the first Carlyle seldom spared himself. In 1824 he published two translations—one from the French (Legendre's "Geometry"), and one from the German (Goethe's "Wilhelm Meister"). The latter work, praised by "Blackwood's" and the "Edinburgh," was attacked by De Quincey in the "London Magazine," to which Carlyle had been contributing his "Life of Schiller." The last chapters of the "Life of Schiller" appeared simultaneously with the unjustifiable attack.

Whatever pain may have been caused by De Quincey was more than assuaged by the commendation from Goethe, who wrote a eulogistic introduction to a translation of the Schiller volume which was published at Frankfort in 1830, three years after Carlyle's period of apprenticeship may be said to have been brought to a close with his studies of "German Romance." Meanwhile Carlyle had met Jeffrey and become a contributor to the "Edinburgh Review," a connection that lasted seventeen years.

Carlyle's Literary Style. One of the real curiosities of literature is the distinction between the form of Carlyle's early writings and that known as "Carlylese," the undoubtedly powerful, but electrical, explosive, ejaculatory style whose beginning may be noted in his "Sartor Resartus," a work of autobiographical as well as of philosophical interest, which, originally published in "Fraser's," first won adequate recognition in America. The student who would read Carlyle aright can do no better than begin by digesting Professor Nichol's masterly monograph in the "English Men of Letters" series. Froude's contentious pages should be left for a later period. Never has any other literary friend performed such a laborious disservice as Froude performed for Carlyle.

Carlyle's greatest works are those in history, sociology, and politics. But there is a great deal in his miscellaneous essays—those on Burns, Johnson, Scott, Voltaire, Diderot, and Mirabeau, for example—that must not be overlooked by any reader who desires to understand the man himself. Carlyle has been greatly misunderstood; but his influence has been almost incalculable in Germany as well as in England. He was "human, like ourselves"; more, perhaps, of an iconoclast and a prophet than a constructive power; but he looked to the "foundations of society," he had a genuine love of truth, and his striving after truth has left to posterity a standard of thought which must remain a permanent social as well as literary force.

The Influence of Carlyle. Essentially masculine in view, Carlyle has yet had a marked influence on women readers. The Swift of the nineteenth century, many a Stella has been his pupil. Appreciations — and depreciations — of his labours there are in abundance, but perhaps Walt Whitman in his "Specimen Days" touched the reality as closely as anyone. "As a representative author, a literary figure," he wrote, "no man else will bequeath to the future more significant hints of our stormy era, its fierce paradoxes, its din, and its struggling periods than Carlyle. He belongs to our own branch of the stock, too; neither Latin nor Greek, but altogether Gothic. Rugged, mountainous, volcanic, he was himself more a French Revolution than any of his volumes . . . As launching into the self-complacent atmosphere of our days a rasping, questioning, dislocating agitation and shock, is Carlyle's final value." Carlyle began life, in a sense, by teaching mathematics in a Fifeshire school; he remained a teacher to the end of the chapter. As a stylist he is the greatest "free lance" in the language: but the reader should beware lest he impute to the leader the sins of his would-be followers, as many a one has sought to thunder in Carlylian strain with the most unhappy results. Where Carlyle's style is concerned we must not judge him by the standard of any other writer; he claims by right to be judged by the vivid and vivifying result. Of no great writer could it be said with more cogency that "the style is the man." His view of his calling is indicated in his lecture on "The Hero as Man of Letters," where he writes:

THOMAS CARLYLE

Carlyle on the Man of Letters. "On the whole, one is weary of hearing about the omnipotence of money. . . . There ought to be Literary Men poor. . . . Who will say that a Johnson is not perhaps the better for being poor? It is needful for him, at all rates, to know that outward profit, that success of any kind is *not* the goal he has to aim at. Pride, vanity, ill-conditioned egoism of all sorts, are bred in his heart, as in every heart; need, above all, to be cast out of his heart — to be, with whatever pangs, torn-out of it, cast-forth from it, as a thing worthless. Byron, born rich and noble, made-out even less than Burns, poor and plebeian. Who knows but, in that same 'best possible organisation' as yet far off, Poverty may still enter as an important element? What if our Men of Letters, men setting-up to be Spiritual Heroes, were still *then*, as they now are, a kind of 'involuntary monastic order'; bound still to this same ugly Poverty—till they had tried what was in it too, till they had learned to make it to do for them! Money, in truth, can do much, but it cannot do all. We must know the province of it and confine it there; and even spurn it back, when it wishes to get farther."

We cannot well in a few words arrive at any plan for the especial study of Carlyle. From the wide range of his writings the general reader will take to such works as his fancy prompts, the student to those his studies suggest, and both may be left safely to come under the all-compelling influence of this mighty and original thinker. The least that should be known of Carlyle's works are "The French Revolution," "Sartor Resartus," "Heroes and Hero Worship," and "The Life of John Sterling." If one begins with "Heroes and Hero Worship," the appetite is more likely to be whetted than by entering the Carlyle treasure-house through the usual gate of "The French Revolution."

Mrs. Carlyle. Almost as interesting as anything Carlyle wrote was the story of his own married life; in some way, indeed, that has been fruitful of more controversy than any of his boldest assertions in the domain of philosophy. JANE WELSH CARLYLE (b. 1801; d. 1866) was almost as notable a woman as her husband was a man, for her "Letters and Memorials" prove her to have been one of the most accomplished women of her time, a shrewd critic, fit to rank with the great letter-writers who have contributed no inconsiderable proportion of our national literature. Mrs. Alexander Ireland wrote an excellent "Life" of Mrs. Carlyle.

It must ever be a matter for regret that the Carlyles, both of whom habitually used words on the domestic level too strong for the expression of their real intentions, should have been paraded before the world in Froude's writings as if they were gallingly yoked together, though their love for each other was profound and unchanging. The marriages of men and women of genius with each other are not so many that the world can afford to see them perversely distorted.

J. A. HAMMERTON

General Conditions of Civil Service Appointments. Details of Emoluments and Conditions of Entry. Examinations.

FIRST CLASS CLERKSHIPS

The schedule appearing on page 1916 summarises for convenient reference the leading features of each general grade of appointment in the National Service. It thus affords, as it were, a bird's-eye view of the whole subject that should prove useful to prospective candidates who are uncertain by which of the many avenues of approach they should seek to enter State employment. In this and succeeding chapters the main outlines furnished by the table are amplified with full particulars respecting each of the appointments in turn. The educational level of the examinations, for example, is more exactly defined by a list of subjects and marks. Meantime the table itself calls for a few words of comment.

First, then, as to the salaries given in Column 5. These are by no means to be regarded as representing the *possibilities* of each class. In almost every instance, ability and good fortune may secure a maximum well in advance of the figures shown. Our aim has been to show not the utmost salary within the reach of individuals, but the amount which, having regard to the constitution of the staff and the conditions of engagement, may fairly and reasonably be anticipated without special promotion or unusually rapid rise in grade.

A Word of Caution. On this matter of salaries the representations of certain Civil Service "coaches" must be taken with a grain of salt. Anxious, for their own ends, to attract candidates to the service, they contrive, while avoiding any definitely false statement, to convey impressions that are far too flattering as to its prospects.

Appointments in the Customs and Excise, for instance, are sometimes advertised in such tempting terms as: "Salary, £80 to £800 a year." But woe betide the hapless youth who supposes from these figures that success in the entrance examination for this grade ensures the maximum salary mentioned! He is fated to be bitterly disillusioned. Among a staff of over 6000 Customs and Excise officers, there are fair chances of attaining a maximum of £450 a year or a little more; but only about fifty members of that large force can hope to reach such a salary as £800. The figures shown in column 5 of our Conspectus represent the average prospects of each grade, as nearly as they can be estimated.

It should be noted that examinations in this service are dependent on the fluctuating needs of its various departments, and therefore are held for the most part at irregular intervals, as well as for a varying number of appointments. In some instances there may be a year or more between the competitions; but those by which the ranks are mainly recruited occur, as a rule, twice or thrice yearly. Columns 6 and 7 of the table furnish useful indications of the number of vacancies to be expected in each grade, and the severity with which they are contested.

A further feature calling for notice is the classification of posts according as they relate to particular offices or to the general clerical staff. Members of the latter are employed indifferently in all the larger departments. A successful competitor for a Second Division clerkship, for example, may find himself appointed to any one of about 60 Government offices, variously situated in London, Edinburgh, or Dublin, and offering very different duties and prospects. The wishes of each candidate, it is true, are consulted as far as practicable, but those who are lowest on the list necessarily receive the appointments that their better-placed rivals have passed over.

Nationality of Candidates. For posts in the national service it is essential, as already mentioned, that candidates should be "natural-born British subjects." This definition includes any person born in his Majesty's dominions, even though his or her parents may both have been lawful subjects of a foreign state. Concerning naturalised aliens and candidates born abroad, the following announcement is made by the responsible department: "A person born in a foreign country who can prove that his father or his paternal grandfather was born in British dominions is, if not expatriated under the Naturalisation Act of 1870, a natural-born British subject." For certain posts abroad, such a candidate needs the permission of the Foreign Secretary. Naturalised aliens can compete for Home Civil Service appointments.

Apart from a few special requirements of the Civil Service Commissioners, to be explained hereafter as occasion arises, the whole range of study requisite for the various examinations is covered by the courses of instruction given in the SELF-EDUCATOR. The consideration of examination subjects need not therefore detain us now. But before passing to a detailed discussion of the several grades of appointment, space may be found for a few general hints—the outcome of personal experience—on preparing for these competitions.

It is essential, in the first place, to realise that they *are* competitions, and that the task awaiting the candidate is not merely to do well in the subjects prescribed, but to do better than the great majority of his rivals. A single mark more or less may mean success or failure, and as the time allowed for Civil Service examination papers is seldom really adequate, the student

must acquire by constant practice the habit of expressing himself tersely, pithily, and to the point. Civil Service competitions, in fact, are severe tests—not only of knowledge, but of ability to marshal that knowledge promptly in orderly sequence. The man who cannot say what he means without much writing and re-writing, like that other type of candidate whose full knowledge of his subject leads him to reply at too great length, cannot do himself justice until much hard discipline has pruned and clarified his habits of thought.

In the actual contest this training will enable him to deal with as much of each paper as his knowledge of its subject matter allows, and thus to secure as many marks for it as possible. Neglect of such a precaution leads candidates into wordy, tedious replies, unfinished papers, and, as a result, a distressing because needless loss of marks.

For the same reason, a speedy, neat, legible hand must be cultivated; and as handwriting is frequently an examination subject in itself, carrying high marks, the particular style of penmanship preferred by the Commissioners should be adopted. This is a clear, running hand, slightly sloped, and wholly free from flourishes, with rounded curves, small capitals, and short loops and tails to the letters.

The Value of Past Papers. An immense amount of effort is uselessly expended by Civil Service students every year for lack of a perfectly simple precaution. They fail to ascertain the precise scope of the examination for which they are preparing, and consequently either waste precious time over features of their work to which examiners attach no importance, or else discover in the examination room that they have underestimated the knowledge expected of them.

Either error might have been avoided by a careful study of the papers set in prior contests of the same nature. Indeed, it is difficult to overestimate the advantages of that course. By a comparison of several sets of old papers the character of the test can be gauged to a nicety, and the work of preparation greatly simplified. The question tests may also be employed for the purpose of "practice examinations"—carried out, as far as possible, under actual conditions, and with special regard for the time officially allotted for each paper. In this way, as in no other, the student can familiarise himself with the trial that awaits him in the examination room. Further, the majority of the sets of questions published by the Commissioners contain tables showing the marks of successful and unsuccessful competitors in each subject, and thus afford a useful measure of the training necessary in order to succeed.

For all these reasons candidates are strongly urged to lay hands on all available papers of recent date for the grade they have in view, and to study them with the greatest care. A list of lately published sets of examination questions, showing the price of each, will always be supplied gratis on application to the Civil Service Commission, Burlington Gardens, London, W. Any set required—if in print—may be purchased, either directly or through any bookseller, from the official agents—Messrs. Wyman & Sons, Limited, Fetter Lane, E.C.; H.M. Stationery Office, Forth Street, Edinburgh; and Mr. E. Ponsonby, 116, Grafton Street, Dublin.

First Class Clerkships. With the exception of diplomatic posts, which are practically restricted to men of good family and social standing, first-class clerkships are undoubtedly the most attractive appointments that the national service has to offer. They constitute the upper section of the general clerical staff in the various Government departments, and are characterised by responsible but not arduous duties, assured position, liberal increments, and a certain prospect of at least £800 to £1000 a year. Nor is this all. Promotions are freely made from their ranks to still more desirable offices, including the highest dignities and most liberal incomes enjoyed by permanent officers of the State.

Salaries Nominal and Actual. Let us consider, first, the assured value of Class I. appointments in themselves. These vary somewhat in different offices, but are generally classified in three grades, advancement being made from one to the next as vacancies arise. In a few departments—notably the Treasury—the maximum attainable without promotion is as high as £1200 a year; but with these exceptions the scale of salaries prescribed does not exceed the following:

Third Class, £200, advancing £20 yearly to £500.

Second Class, £600, by £25 to £800.

First Class, £850, by £50 to £1000.

The remuneration for many of the posts offered is fixed on a less liberal basis. Beginning at £150, it rises by £15 yearly to £300, thence by £20 to £500 or more, and afterwards by £25 to £800 or £900.

Owing, however, to the special emoluments and liberal opportunities of promotion enjoyed by these clerks, the above rates by no means represent the real value of Class I. appointments. Many juniors are appointed as private secretaries to the principal officers, with extra remuneration of from £50 to £300 a year, and more senior members are eligible for departmental secretaryships and other leading staff positions at various rates between £1000 and £1800 a year. As a result, advancement is so brisk that the official scales of salary already quoted are, in practice, only minimum rates, and generally prove little more than nominal.

Examples of Promotion. Such an assertion is best proved by actual illustration. The following instances will serve to establish the point. A successful competitor who entered the Inland Revenue Department, with an initial salary of £150 and a £15 increment, received within a year a private secretaryship at an extra £50 yearly, and later another worth £100. After less than nine years' service he became a principal clerk at £600 rising to £700, when his stipend according to the official scale would have been £270. A colleague in the

same office was even more successful, attaining the rank of principal clerk after only six years. In another instance known to the writer a clerk of two years' standing was advanced in salary from £150 to £350.

Of the posts attainable by senior officials, a few cases among many must suffice. The present Chairman of the Prison Commission entered as a Class I. clerk in 1881; he long ago attained £1800 a year, and has had a K.C.B. conferred on him for his services. Another officer, after some twenty years' service, became Chairman of the Board of Inland Revenue, with a salary of £2000. Other highly placed officials who entered by the same means include the Assistant Secretary of the Treasury (earning £1500 a year), a Secretary to the India Office, and the Director of Admiralty Stores, each receiving the salary of £1200, and at least three Assistant Under-Secretaries of State at the same remuneration.

The Age Limits. Class I. clerkships, as well as Ceylon cadetships and appointments in the Indian Civil Service [see Imperial Service], are awarded on the results of a joint open competition held in August of each year. Candidates who are eligible may enter simultaneously for all three classes of appointment on payment of a single fee; and, if successful, are allowed, according to their position on the combined list, to select which service they will enter.

Competitors for the posts under discussion must be between 22 and 24 years of age on the 1st August of the year in which they enter, but are entitled to deduct from their actual age any time spent in the naval or military service. A further and valuable provision enables those who have been for two years or more in the national Civil Service to deduct in the same way the time so employed, up to a maximum of five years. Subordinate members are thus generally entitled to compete until the age of 29 years.

The Examination Subjects. The examination subjects and the maximum marks assigned to each are as follows:

Mathematics and advanced mathematics, 1200 *each*. Sanscrit and Arabic, 800 *each*. English, French, Italian, German, logic and psychology, moral philosophy, political economy, and the following branches of natural science—chemistry, physics, geology, botany, zoology, and animal physiology—600 *each*.

English composition, Greek history, Roman history, general modern history, political science, Roman law, and English law, 500 *each*.

English history (i.) to 1485; (ii.) 1485 to 1848, 400 *each*. Greek: translation and composition, 400 *each*; and literature, 300. Latin, in similar divisions, corresponding marks.

Candidates may not offer more than four natural sciences, and those who select Latin or Greek must take up translation, and at least one other division of the subject. To hinder mere "smatterers" from succeeding by sheer multiplicity of papers, a deduction may be made from the marks gained in each branch. There is also a provision that a competitor's papers shall not carry a greater total maximum than 6000 marks. Its effect is to limit each student to some ten subjects, or twelve at most.

Choice of Subjects. With these restrictions, any of the branches named in our list may be taken, none being obligatory. The choice thus afforded is a very wide one; and, as the examination standard in each subject is very severe, it is imperative that a careful selection should be made at the outset of the course of study. In practice, it is found that successful contestants who are not brilliant mathematicians usually take up classics or modern languages as a mainstay, with history and law or moral sciences as supplementary mark-getters, the natural sciences being seldom taken seriously. Until recently, indeed, classics were regarded as almost essential to success, but the waning importance of this branch of a liberal education is already reflected in the Class I. pass-lists. High marks in English subjects, mathematics, and either natural sciences or three modern languages, now frequently secure a good place, though the majority of successful candidates still take the classical subjects.

From 20 to 30 vacancies in the home service are usually filled by competition each year, but occasionally the number rises to 50 or 60. At the joint examination, some 200 to 220 candidates sit each year. Of these, the great majority compete for the home as well as the foreign service, deciding afterwards, if successful, which branch they will enter. Badly placed candidates often prefer an Eastern post to indifferent offices in the home service; but those who stand high enough to secure a good choice of departments generally select the career afforded by a Class I. appointment. These facts are strikingly illustrated by the latest report of the Civil Service Commissioners, which shows that 168 in a total of 216 contestants entered for Class I. clerkships, and, of the first 11 successful competitors on the combined list, no fewer than 8 accepted these appointments in preference to posts in the East.

University Prizes. When we consider the keen competition for these positions, the large number of subjects essential for success, and the searching character of each paper, a doubt arises as to whether Class I. clerkships are within the scope of any private student, or of a subordinate civilian who has only his evenings free for study. The doubt is more than justified, alike by personal knowledge of the many hard-working minor officials who have striven vainly for these posts, and by the published results of recent competitions. The men taking high places on the list have come from the honours schools of the sister universities, in many instances with a post-graduate course of some months in a "crammer's shop" just before the examination. Only a single post during the past two years has been won by a candidate who had not had the advantage of a college training. Reluctantly we are driven to admit that, unless when some intellectual marvel is the exception that proves the rule, these valuable appointments are practically close coverts for the brilliant men of the universities, and especially of Oxford and Cambridge. ERNEST A. CARR

Herbert Spencer's Notable Contributions to Biology. The Continuous Adjustment of Life. The Law of Recapitulation.

THE WORK OF HERBERT SPENCER

LAMARCK was in advance of his time, and failed to convince the world. But the free-minded thinkers of the first half of the nineteenth century numbered a few who kept on wondering whether the theory of "transformism" might not be true. The idea that accidental fitness would ensure survival, and that thus there might be a process of "natural selection," was a helpful one. It independently occurred to several students. Of these by far the greatest was Charles Darwin, whom we must later study. Alfred Russel Wallace was another. Earlier writers are quoted by Darwin in his historical sketch in the "Origin of Species."

The Gradual Recognition of Spencer. Lamarck himself had not thought of the principle of selection, clearly because he was concerned with finding some *positive* explanation of the production of new forms, and in such a search a thinker so profound as Lamarck would not be led aside to a theory which only explains the destruction of the least-adapted. Similarly the idea of selection was absent from the teaching of Herbert Spencer, the only philosophical thinker worthy to name in biology between Lamarck and Bergson.

The immense and undue emphasis laid on natural selection in Herbert Spencer's own country has long led to his comparative neglect here. It was generally thought that he, like Lamarck, had missed the great clue which Darwin—and, as we now know, many others—had found. But the modern criticisms of such authors as Driesch and Bergson have now profoundly altered our estimate of the value of natural selection—to say nothing of the new estimate which must follow from the experiments of the Mendelians alone; and we may begin to appraise Herbert Spencer more justly.

He was somewhat in the position now occupied by Bergson. The actual biologists resented his incursion into their field. To them he was merely a word-spinning philosopher, writing at second-hand of things which they were actually studying. The physiologists and less philosophical biologists speak in exactly the same way of Bergson today. But already we all think in Spencer's terms, and use his ideas continually, though many of us may be unaware of the source of our principles.

Spencer's Rejection of "Special Creation." In the 'forties and 'fifties of the last century Spencer was writing essays which dealt with various aspects of what, in 1857, he decided to call evolution. He used this word because he had seen that "progress," a term which he had formerly employed, was inadequate. Retrogression and degeneracy may be and often are part of the process of ordered change which he called evolution; and those today who use the word evolution as if it meant progress and appeal to it as a beneficent power which does not need our help, are missing the whole reason for which the word was given its present meaning.

Spencer found the accepted theory of "special creation" incredible. The only conceivable alternative is "transformism," "development," or "evolution" of living species, which Spencer always saw and conceived of as part of a universal process. Thus there are stellar and atomic evolution; and that which here concerns us is organic evolution. But what of "mind"? Is organic evolution to deal merely with organisms, as the term would suggest, and to ignore the mind, as orthodox biology still does; or are we to look upon the evolution of mind as going along with the evolution of the material structures we call living organisms? For Spencer there could be but one answer; indeed, he wrote upon the evolution of the mind before he attacked the more general problem.

"The Principles of Psychology." We must honour his name as that of the first thinker who saw that mind must be studied *in all its manifestations*, and not merely as found in the case of the particular philosopher who is considering it. To Herbert Spencer we owe the modern idea of psychology, which pervades all our thought and all our research everywhere—that the philosopher must not merely study mind as a finished, fixed, constant thing, existing in himself, but must look at and compare *all* the kinds and manifestations of mind that can be seen in the living world. We must study not merely the mind of adult Caucasian man—and his only when of the particular type found in abstract thinkers—but also the minds of women, of artists as well as thinkers, of savages as well as civilised man, of children as well as adults, and of animals to boot. Such familiar ideas, which are unquestionably sound, we owe to Spencer, and his "Principles of Psychology," first published in 1855, will always be a classic accordingly. Today we study mind *evolutionally*, because he taught us to do so.

Triumph of the Spencerian Methods. We send expeditions to study the minds of savages. We devote endless labour to the study of children, who give us stages in the growth of that living, dynamic, moving, evolutionary thing, the human mind; though no philosopher before Herbert Spencer had thought such a thing consonant with his dignity. Nay, more, such naturalists as Mr. Ernest Thompson Seton are studying the minds of animals, and many botanists are looking for, and finding, evidence

of what can only be called *behaviour* in plants. The Spencerian view of mind and the way in which it must be studied have entirely triumphed. As we have said elsewhere, "He was the first man to realise effectively that mind has a history."

The Suggested Evolution of the Eye. The most notable instance has to do with one of the noblest and most valuable of senses, vision. Following the outlined theory of a remote predecessor, Herbert Spencer argued in a fashion which Professor Tyndall, on a famous occasion, thus rendered:

"In the lowest organisms we have a kind of tactual sense diffused over the entire body; then, through impressions from without and their corresponding adjustments, special portions of the surface become more responsive to stimuli than others. The senses are nascent, the basis of all of them being that simple tactual sense which the sage Democritus recognised 2300 years ago as their common progenitor. The action of light, in the first instance, appears to be a mere disturbance of the chemical processes in the animal organism. By degrees the action becomes localised in a few pigment-cells, more sensitive to light than the surrounding tissue. The eye is here incipient. At first it is merely capable of revealing differences of light and shade produced by bodies close at hand. Followed as the interception of the light is in almost all cases by the contact of the closely adjacent opaque body, sight in this condition becomes a kind of anticipatory touch. The adjustment continues; a slight bulging out of the epidermis over the pigment granules supervenes. A lens is incipient, and, through the operation of infinite adjustments at length reaches the perfection that it displays in the hawk and eagle. So of the other senses, they are special differentiations of a tissue which was originally vaguely sensitive all over."

Life's Replies to Nature's Problems. Here is an epoch-making statement. It boldly offers the view, monstrous if not blasphemous when it was first promulgated, that the eye and the sense of vision were not specially created as we know them, but are evolutionary products: and it suggests the stages through which their evolution has proceeded. But we must beware. The unwary may read, have often read, such a passage, and have supposed that it contains an *explanation* of the evolution of the eye and of vision. It contains nothing of the sort. It offers, for the first time in modern thought, a true description of the historical facts, as distinguished from the false description involved in the theory of special creation. But when we attempt to value the meaning of the words we employ—which is an essential business in any real thinking, as Bacon pointed out long ago—we see that explanations of evolution are still to seek. "Adjustments" are made, we have said. But how, and by what?

That this is no mechanical business we learn when we see that similar eyes have been formed along wholly divergent lines of evolution. Further, Bergson has taught us that the successive adaptations involved in the evolution of the eye are not mere mechanical echoes or repetitions of the environment, but are *replies* made to problems put. Each new structure such as the eye means a problem solved. But what makes the replies, what solves the problems posed by inorganic Nature? The only possible reply is Life, and we merely fool ourselves if we suppose that we are not now thinking of something psychical.

Herbert Spencer, of course, faced this ultimate problem of all biology—the nature of life. It is curious to observe how constantly men of science discuss the problems of evolution without realising that this is the problem which underlies them all. It is life that evolves, and according to our theory of life will our theory of evolution be. It is customary to call Herbert Spencer a materialist, though indeed, like all men of science, he did no more than recognise and honestly insist upon the material and mechanical element in life. But he was not a materialist in the only legitimate sense of the word, which means a man who believes that mind is the product of matter, the soul the product of the body. Spencer has given us two contributions to this subject, each noteworthy and memorable.

The Continuous Adjustment of Life. First, there is his famous phrase that "Life is the continuous adjustment of internal to external relations." No words could more accurately describe the behaviour of the living organism. Its parts are in a highly complex series of relations to each other, and "to live is to change." At every moment there is a continuous modification of the living organism and the relations of its parts, in response to the ever-changing environment. Physiology is concerned from first to last with the study of this "continuous adjustment." On the whole, also, we may recognise in this description something which distinguishes living from lifeless objects. When, for instance, a living being dies, its corpse is modified by the environment, is acted upon by the environment; but what has ceased is *its* adjustment of itself and its internal relations to the environment, in order that it may live.

But those were wrong who supposed that Spencer had given us in this phrase a definition of the nature of life. As we have pointed out elsewhere, his phrase really requires a too significant addition. We should have to say that Life is the continuous adjustment of inner to outer relations by Life; and then we see that our description of Life's procedure is not a definition of Life. Spencer knew this well. He pointed out that Life displays itself in matter, the ultimate nature of which he described as "Unknowable." Life, therefore, he concludes, must be and is doubly unknowable. So much for the accusation that he was a materialist.

Spencer a Lamarckian. But he certainly was a Lamarckian, and he is all the more significant for us today in that he was. From the first to the last, though accepting and utilising the theory of natural selection, which he elucidated further by calling it "the survival of the fittest," Spencer maintained that influences playing upon parents affect their offspring, and that the great,

central fact of adaptation may be in part thus explained. He asserted, with Lamarck before him, and in agreement with Darwin himself, that not merely natural selection can account for the adaptation or fitness of organic beings to their environment. He declared what, in this country, for several decades, has been looked upon as a heresy—that natural selection is less important than "the transmission of acquired characters" as a cause and explanation of adaptation.

Many and notable were the passages-at-arms between, for instance, Herbert Spencer and August Weismann on this point. Spencer declared the certainty of his conviction in the assertion that either there has been transmission of acquired characters, or there has been no evolution. He, the apostle of evolution, who asserted its presence in all the facts of the Universe, could say nothing stronger than that. In his own country, thanks to the influence of the followers of Darwin, the verdict went against him; but the Lamarckian theory always had notable champions in the United States, as, for instance, in Cope, who wrote a book with the pertinent title, "The Origin of the Fittest"; and in France, ever since the fact of organic evolution was accepted, the Lamarckian theory of the process has been generally accepted.

The Limitations of Mendelism. The great new (re-)discovery of our time, in the field of heredity, is Mendelism, and so great are its triumphs that we may easily be led to attribute to it an *ultimate* significance which it does not possess. That is an error not shared by Professor Bateson, the living leader of the Mendelian school, in his recently published "Problems of Genetics," or in his previous works. He knows, and we, before we study Mendelism, may note, that Mendel's law does not account, in any degree at all, for *adaptation*. It tells us how certain characters are transmitted, with a degree of prophetic accuracy unknown hitherto; but it also shows that many of these "Mendelian characters" have nothing to do with adaptation, and, indeed, there is no fact of adaptation which Mendelism so much as begins to explain. Yet adaptation is the central fact of the living world, and is the very heart of the problem of evolution. Given the myriad exquisite adaptations displayed by living beings, and denying that God made them as such, science must find a theory of evolution which explains them. Certainly natural selection does not, as we shall see, and certainly Mendelism does not, as we now learn in anticipation from Professor Bateson himself. We must go back to Lamarck in our difficulty, and to Herbert Spencer, who kept the Lamarckian flag flying even in our own century.

The Law of Recapitulation. Spencer took over from Von Baer, and used with effect, the famous law of recapitulation, which asserts that, in development, each individual passes through stages which correspond to the history of its race. This law has also been very largely used and illustrated by Professor Haeckel, of Jena, now the last survivor of the early days of organic evolutionary theory. Haeckel also agrees with Spencer in being a convinced Lamarckian, and he is living long enough, as Spencer did not, to find a hearing for this view again, even outside France.

The fact of recapitulation is impossible to explain, so far as we can see, except on the ground of "inherited memory," or some such theory. It can be of no advantage to the individual, can have no survival-value, and is therefore in no way to be explained by the Darwinian theory of selection and survival of the fittest. On the contrary, many consequences of the law of recapitulation are the very reverse of advantageous. Many a man dies of asphyxia because his food, in reaching the gullet, has to be thrown perilously across the opening that leads to the lungs. If Life had had, so to say, a fair start and a clean slate, it would never have made such an arrangement. The only explanation of it is that the lungs are evolved from the swim-bladder of a primitive fish, the opening of which lay, in the fish, *below* the opening of the gullet. That this arrangement, long irrelevant to our upright and air-breathing race's needs, should be repeated in the history of every human individual, can only be explained by the view that Life "remembers," so to say, not merely throughout the history of the individual, but also from generation to generation. Such a view is essentially Lamarckian.

It is not necessary here to note the various minor contributions of Spencer to biology. It is enough for our purpose to note that this country produced an evolutionary thinker who accepted and elaborated the views of Lamarck before Darwin's work, to which we must next proceed, was given to the world.

The Range of Spencer's View. Spencer's view of evolution was not limited to any one school. He accepted Lamarck, and he accepted Darwin. Today, when we realise how little we know of the *how* of the evolutionary process, we may be grateful for all the help that each of those students may afford us, and for Mendelism, too. We need them all and more—much more. At the same time, Spencer taught that "only the manifestations of life come within the range of our intelligence, while that which is manifested lies beyond it." In such a statement we find grounds for a view of organic evolution which recognises purpose, internal, vital direction within it, due to Life itself—the view of Driesch and Bergson.

The Jewish thinker has very severely criticised, at the end of his "Creative Evolution," what he calls "the false evolutionism of Spencer." But it may be doubted whether he has done justice to the Englishman, whose works are certainly voluminous and not easy reading even for English students. All who write in French are, in the first place, indebted to Spencer for his championship of Lamarck, and it is certain that but for the English thinker we could not have had the "Creative Evolution." It was Spencer's magnificent, comprehensive, and courageous survey of the facts of the living world which enabled his successor to plough more deeply and raise a finer crop.

C. W. SALEEBY

Modern Developments of an Old Invention. What the Card Index is. Adaptability of the System. Records in the Sales Department.

THE CARD INDEX IN BUSINESS

If the question were to be asked of a number of commercial men: "What invention has proved of the greatest benefit to business generally?" it is quite likely that the answer most generally given would not be the telephone or the telegraph or the typewriter, useful though these things are. The most probable reply from nine out of every ten business men would be, "The card index."

Of course, any such general question is extremely difficult to answer, and the inventions already referred to, with a score of others, have been of such inestimable advantage to business that it is impossible to make distinctions save in a very arbitrary way, or to say that this one or that one has proved more valuable than all the others. It is certainly true, however, that the invention of the card index has worked a complete revolution in many departments of business, and has made it possible now to record and analyse returns in a way that was previously quite impossible. In fact, now that we have the card index with us, and use it in almost every department of a great business, it seems remarkable that the system did not come into general use at least a century earlier.

Advantage of the Card Index System. Its advantages over the old, clumsy books, from the point of view of simplicity, ease of handling, and accuracy with which details can be recorded, needs no emphasis here, and the time and trouble saved in the opening of new books when the old ones were filled up—as in the case of ledgers, address books, and so on—has put pounds into the coffers of business houses.

The Card System not New. The card index system is generally looked upon as something very modern, and, indeed, it is, so far as its widespread application to commercial life and procedure is concerned; but, as a matter of fact, the system was used in a more or less simple way over a century ago. So far back as the end of the eighteenth century a Frenchman named Rozier—an ecclesiastical official—is said to have used loose cards in compiling an index to the books of the Academy of Science in Paris. There is little recorded beyond the fact, but Abbé Rozier is usually regarded as the inventor of the card index system, and his name should certainly be held in honour, for by inventing this system he reduced in an almost indefinite degree the time and labour which would otherwise be involved in libraries, business houses, and other places where long lists of books or names and addresses or statistics have to be kept.

Modern Developments. But although it is to a Frenchman that we owe the original invention of this wonderful and useful system, it is really to our American cousins that we owe its development on scientific lines, so that it is now available for every kind of record work. Its great beauty lies in its adaptability. It first came into general use for cataloguing library books, but keen observers were quick to see its possibilities in the business world, and it was not long before clever commercial men with scientific minds had set to work to devise methods of applying it to every department of business life. Its value was so obvious that it quickly came into use in all up-to-date and go-ahead firms, and actually gave rise to a new industry, the provision of office furniture on labour-saving lines. Special drawers and bureaus to hold the cards were quickly followed by more elaborate filing cabinets for every kind of document, and now in London and other large commercial centres there are many businesses supplying office requisites of this and other kinds to business firms. It is out of the card index that all the modern methods of filing have arisen, and they are really nothing more than adaptations and elaborations of the card system.

Statistics at a Glance. The card index not only enables lists of names and addresses, estimates, purchases, sales, and so on to be kept in such a way that the lists can always be added to in correct alphabetical, numerical, or any other order, but it also enables records such as those of sales, for instance, to be analysed and examined, and the relative value of the figures to be seen and appreciated in a way that was impossible under the old book system. Even with a large staff working to prepare returns, it would have been impossible under the old system to have seen so clearly from book records what is evident at a glance from the work of a single clerk on the card system. For all such work as classifying miscellaneous information and figures, grouping together facts of the same kind, and so on, work that must now be done in all railway offices, banks, gas and water offices, and mercantile concerns, the card index is indispensable. Even a small retailer would save himself endless trouble and time if he were to use the system for his bookkeeping records.

What the Card Index is. The card index is really a system in which cards of a convenient shape are used, instead of the pages of a book. A separate card is used for each name or firm whose address or record is to be kept, and as the cards are loose and can be easily removed, new names and records can be inserted in a moment in their proper alphabetical or numerical order, and any dead names or information that is no longer wanted can be removed by taking out of the drawer the card or cards containing it.

Adaptability of the System. The card index enables a list of names or facts or figures to be arranged alphabetically, numerically, geographically, chronologically, or in any other order, and a single set of cards, by means of cross references, may embrace all these arrangements in one system. Various standard ways of working the card index are in vogue, but its utility is not confined to these, and any business of a peculiar nature for which ordinary office methods are not available or practicable can always adapt the card index to its requirements. New ways of using it are constantly being found out, and without a knowledge of its advantages no man can possibly hope to take high rank in the business world.

The Simplest Form of Card Index. In its simplest form, the system is as its name implies just a card index—a list of names or titles or articles in which each name occupies a single card. The cards are then arranged in a drawer or drawers according to alphabetical or any other desired order, and as fresh names need to be added to the list, these, as already explained, are written on new cards, and the cards inserted in their correct places. The index is thus available for all time and never needs remaking, as in the copying out of names from an old into a new book, when the former has become filled and the lists are disarranged owing to names having been put in out of alphabetical order. The cards can be bought very cheaply, and they are kept in place in the drawer by means of a long rod that runs through the perforations at the foot of each card, and is fastened by a screw at the front of the drawer.

For ease and convenience in consulting, index guides are placed at intervals, with tabs projecting above the cards, bearing the initial letter of each section. These tabs on the guide-cards are arranged further to the right in successive guide-cards, so that one shall not interfere with or be obscured by another. Thus the first guide-card would be for "A," and the tab would be to the extreme left; the next would be "B," and the tab would be in the middle of the card; while the next would be "C," and would have its tab at the right of the card. Then "D" would be at the left, "E" in the middle, and so the changes would be rung up to "Z." Of course, if desired, there could be four positions for the tabs, and the guide-cards could be even more divided, thus: "Aa to Ah," "Ai to Al," "Am to Az," "Ba to Be," and so on.

Division of Labour. Apart from its elasticity and its never-failing alphabetic sequence, another advantage of the card index over the old book system is that in case the names and addresses and facts have to be copied out, as when envelopes are addressed, they can be divided up among a number of clerks, whereas a book can be used by only one man at a time.

Even a mere list of names and addresses can be made extremely useful by the addition to the cards of much valuable information, as, for instance, telephone numbers, telegraphic addresses, the cable code used, and so on.

Use of the Card Index in Filing. The great value of the card index in the filing of letters and documents has already been emphasised in the chapter on correspondence, and needs little further explanation here. All the valuable information contained in letters, which under the old alphabetic system of filing letters was buried, can be made available at a moment's notice by the simple means of indexing on a card the subject, and inserting the card in its proper alphabetic order among the names in the card index. Thus, six successive cards might read: "Apjohn, Henry; Appleby, Thomas; Apples, Prospective crops of; Artist, Useful commercial; Attwell, Charles; Aubrey, John." The card index, it must be remembered, is always just big enough, and never too big.

The varied and miscellaneous information contained in letters and other documents should only be indexed if it is likely to be wanted and to prove useful at some future time. Of course, the indexing, like everything else, can be carried to an extreme, and this waste of time and energy must be guarded against.

The Card Index in the Selling Department. The usefulness of the card index in the buying and costing departments and in the stores has already been referred to, and no further details need be given here. It is, however, in the selling department that the system proves of greatest value. By its means analyses of sales can be made as often as desired, with the minimum of trouble, the activities of the various travellers can be followed closely week by week, or month by month; the state of trade in the various districts and towns can be noted, and the rise or fall in the amount of business done with any particular customer can be seen at once.

It will be agreed that such a variety of information—much of it of vital importance to the firm—must be of supreme value, and if it were by its usefulness in this department alone that the card index was to be judged, it would have more than justified itself. The use of the card index by a selling department may be simple or complex, according to the requirements. Different sets of cards can, of course, be kept to record varying phases of the selling side of a business, or a single set can be so arranged as to achieve two or three objects. The best system will soon occur to a man who has a grip of its idea.

A Simple Use of the System. The simplest method of all is to have a series of cards, one for each customer, with vertical and horizontal lines dividing the card into a number of spaces for the figures. Down the left-hand column of the card, running from top to bottom, with one or two lines for each, are written the abbreviated names of the twelve months—Jan., Feb., Mar., etc., as shown on the part of a card of this kind given at the top of the next page. The vertical columns will represent different years—1913, 1914, and so on, one year being written at the head of each column. On a card arranged in this way the monthly sales of a customer can be entered up, and when full it will be a complete record of that

customer's purchases for five or six years. The card would be entered up like this:

Name, Smith & Co. Terms, 2½ %. Traveller, J. Brown. Address, 1a, Bull Street, Glasgow. No. 107.					
	1912	1913	1914	1915	1916
Jan. ..	£126	£153	£170		
Feb. ..	£130	£201	£180		
March ..	£90	£181	£217		

At the head of the card is written the name of the customer, with his address and the terms on which he is supplied, and also the name of the traveller on whose territory the customer is situated. A series of cards made out in this way, and posted up to date, is an exceedingly valuable record, and will prove particularly useful in a small business where it does not take very long to look through the whole of the cards. The disadvantage in a large business would be that the cards would have to be kept in alphabetical order, and would be principally a record of the business done with customers, and nothing more. If it were desired to know the state of business on any traveller's territory, then it would be necessary to go through the cards, and rearrange them according to the travellers' names. This would involve a great deal of long and tedious work, if the business were an extensive one with some thousands of customers, and in order to avoid it various adaptations of the card system have been tried, all of which are good in their way. It must, of course, be understood that different businesses need different methods, and so brief particulars will be given of some of the systems, and every business man must judge for himself which is the best to follow in his own particular selling department. In all cases the cards should be given numbers, so as to facilitate cross references between one set and another when necessary.

Different Sets of Cards. A good many firms elect to have two sets of cards. One set will be like that described above, which will enable a complete record of any customer's account to be turned up in a moment for examination. Then in order that returns of the different travellers may be examined with equal facility, it is the practice to have a number of cards made out according to towns. At the head of each card is the name of the town, the traveller who works the territory, and the year. There are vertical and horizontal rulings, and on each horizontal line is written the name and address of a customer in that business, the number of his card in the other set, and the amount of business done with him in each month of the year, with the total for twelve months in the last column. The card has about eighteen horizontal lines, so that it will hold the records of eighteen firms on one side. It may then be turned over, and the record for that town continued on the other side in the same way. In this way a single card will contain the records of, say, 36 customers. The specimen of a part of the card given below will illustrate better than any description how the record is kept.

Town, Barton.			Traveller, F. Jones.									Year 1913.			
No.	Name.	Address.	Jan.	Feb.	Mar.	April.	May	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
			£	£	£	£	£	£	£	£	£	£	£	£	£
17	Appleton, E.	6, May Street	15	10	5	7	8	3	10	11	7	10	5	13	104
25	Aylmore, J.	17, The Close	6	3	10	10	7	9	11	3	13	4	12	10	98
121	Brown & Co.	1, Market Hill	22	14	20	17	31	10	23	30	12	15	31	21	249

Avoiding Double Sets of Cards. Such a system works well enough, but the objection to it is that it necessitates a double set of cards. In order to avoid this, cards of different colours are often used. The accounts of different travellers are made out on different coloured cards, and though cards are entered up and arranged like those first described—alphabetically according to customers' names—yet any particular traveller's records can very soon be picked out and put together for examination, or can even be examined while they remain in the open drawers, because they are so easily distinguished from others by reason of their distinctive colour. Thus, Mr. Brown, who does the North of England, might have yellow cards; Mr. Jones, who does the Midlands, buff; Mr. Robinson, who does the Eastern Counties, could have red; Mr. Smith, who does the South-East of England, mauve; Mr. Evans, who does Wales, blue; Mr. Roberts, who does Scotland, pink; Mr. Jackson, who does Ireland, orange; Mr. Hobson, who does the Southern Counties of England, grey; and so on to any extent. In order to facilitate the handling of such a multi-coloured set, it is usual to have cards that are scalloped at the top, or have tabs sticking up so that the cards of different colours may show up plainly and be picked out with the minimum of trouble.

Different Arrangements of the Cards. The cards with the customers entered up according to towns, or those with a customer on each card, can be arranged alphabetically as a whole, or they can be kept in groups according to the different travellers' territories, each group being alphabetical in itself, whether towns or customers. The first set of cards described is very serviceable where the firm's business is confined to one or two lines, but where there is a large range of goods a more detailed record is needed, if the sales are to be properly analysed and followed up by the selling department. In such case it is usual to have two sets of cards, one set being a record for two or four years only, with one or two years on each side of the card, the other set being a summarised record for about ten years. This second set of cards is practically the same as the first set described in this chapter, and is useful for extended reference when it is wanted to compare a customer's trade for a number of

years to see whether there has been a progressive increase, a decrease, or an up and down switchback kind of trade.

Work of the Sales Promotion Department. It is the detailed analysis of the sales for two or four years, made out on a single card, that is the record on which the sales promotion section of the selling department will base all its work. In this case the card will bear at the top the name and address of the customer and the name of the traveller. There will be the usual horizontal and perpendicular rulings. In the left-hand corner will be the names of the months one under another, one line for each month of the year. Then the rest of the card is divided into narrow columns, and at the head of each is written the name of one particular line of goods. There may be on one particular card room for thirty lines of goods, with a column for each. In this case the whole side would be required for one year; but if there are only twelve or fifteen lines of goods, then two years can be got on the front of the card, side by side, and two years on the back. The business done with each customer is now entered not up in a lump sum, as in the simpler form of record, but is analysed, and the amount spent on each particular line is entered in its proper column.

The Value of the Record. This record is exceedingly valuable to the selling department, and enables them to work scientifically and systematically in promoting sales. In the old days it was the custom to look at a traveller's total returns or a customer's gross turnover; and if on comparing these with a previous year or period it was found to be up, then everything was considered satisfactory. But such a crude method of doing things is not now considered of any use. A traveller's returns may be up, and yet he may not be doing the business the firm wants—the business that is most profitable to it. He may be merely getting the business which is easiest to get and neglecting that which is most desirable to get. It is only natural that, if there be no such analysis as has been described, the traveller should be left to his own devices, when he will push those goods that are sold with the least expenditure of energy and trouble.

The Right Kind of Selling. No traveller should be allowed by his sales manager to ignore any lines turned out by his firm; and when an analysis is kept by the card index system, as described, the sales manager can have a weekly statement of each traveller's doings placed before him. Thus, if Smith, in the Eastern Counties, has sold plenty of butter, but no cheese, he should be given a reminder or spur regarding cheese; and if the travellers generally are neglecting any particular line, as shown by the records, then there should be a general spur all round on this line. There may be some particular reason why the line is not selling well. In such a case the spur will have a good result, for the travellers, in self-justification, will write in, explaining why they are not selling it, and the sales manager will then be able to look into the matter and see if there is anything wrong with the line or with the terms. He may be able to give better terms, to hit on some scheme to make the line more attractive to buyers, or he may find that his men have not got the right selling story.

Following up the Records. Some firms pay so much attention to these statistics, and attribute such importance to them, that they have their men down from time to time and place their records before them, giving them the straight hint that they must move the lines they are individually neglecting. No selling department should be content to go on without an analysis of its travellers' work kept in this way. There is an added inducement for the travellers to work when they know that their returns are being systematically scrutinised.

Watching the Purchases of Buyers. What is true in the case of the travellers' returns is equally true in the case of the purchases of buyers. If the fullest value is to be got out of the statistical department, then the business of each individual customer should be analysed and records made according to the different lines the firm deals in. The sales promotion department will then go through the customers' cards periodically, making notes of those who are down on their gross turnover, and of those who, though their general business has increased, are down on certain lines. Individual letters will be written to these customers, and the result will undoubtedly be to draw new business. Nothing brings about such good results in selling as the persistent following up of customers by the selling department. It will be seen who are the big buyers of certain goods; and when there are special lines that want clearing quickly at a special price, then from the card index records can be found out who will be the most likely buyers. This enables the lines to be cleared with the minimum of trouble and expense, the profits, of course, being correspondingly greater than they would otherwise be.

Looking after Prospective Customers. The card index system is absolutely indispensable in a modern selling department. By it returns can be recorded and analysed, and comparisons made in a scientific way that would be impossible by any other system. In addition to the records of existing customers and trade already done, various other records can be kept which cannot but prove useful, as, for instance, particulars of prospective customers from whom inquiries have been made, and to whom samples or price-lists have been sent. These, then, can be followed up in a persistent and systematic way.

The Card Index System Pays for Itself. The hesitation of some firms to the institution of a record department based on the card index system is the cost of it, and certainly it is true that it will cost money. A staff will be necessary, as the examination of all the orders and despatch notes, and the entering on the cards of the returns, will involve a great deal of work; and if the business is a large one

several clerks will be needed for this. In addition there will have to be a smart man at the head of the department, and such a man can command a good salary. But if the records are properly used the investment is one that will bring back returns every day. Some firms have found their business double in a comparatively short time after they have installed the card system, and set to work using the statistical branch of their selling department. It must, of course, be understood that strict accuracy is necessary, which merely means that those engaged upon the work must take an interest in it and do it with care. Nothing in the way of slipshod work can be tolerated in the handling of statistics.

The Card Index in the Advertising Department. Another department of a large business house in which the card index is extremely useful is the advertising department. Here, if a considerable amount of advertising is being done, records must be kept of the different forms of advertising—notices in the Press, posters on the hoardings, stands at exhibitions, railway advertising, and so on; and this can only be properly done by means of the card index. If a regular list of newspapers is systematically used at more or less regular intervals, then there should be a card for each journal, with its name at the top; and if the space occupied is always the same—say, a half-page or six inches double column—then the space should be mentioned at the top of the card, too. The intervals at which the advertisement appears should also be stated. Then there will be the usual horizontal and perpendicular rulings, the columns can be headed with the dates of the weeks or months in which the advertisement is to appear, and as the voucher copies come in with the different dates a tick can be placed in the spaces for these dates. Thus a complete check will be kept on the appearance of the advertisements, and a full record of the advertising will be available for consultation at any time. If columns be left for the cost per insertion, the cards will also provide a record of the money that is being expended.

If the firm has running contracts with the different papers and magazines, then the other side of the card can be used for a periodical balancing to see how much of the contract has yet to run. Here there will be columns for the description of the advertisement, the number of times it is to appear, the intervals of publication, the price per insertion, and the balance still to run. Where the advertising is not so extensive, and is not done on contracts, the card index system is nevertheless equally useful, and provides a much better record than any book or set of books could possibly do.

Keeping the Card Index Within Bounds. Methods of adapting the card system to other forms of advertising, such as bill-posting, will at once occur to the mind of any thoughtful business man. In every way it will simplify the work of the advertising department, and in all up-to-date firms, whether of newspapers or commercial houses, it is regarded as essential. It must always be remembered, however, that the system must not be allowed to run wild. It should be used only where it is really useful, and not merely for the compiling of records that are of no real service to anybody.

Keeping Track of Follow-up Letters. The systematic sending out of form letters, too, is a matter that can be greatly helped by a judicious use of the card index system. It may, for instance, be determined to send out a letter to every one of a number of possible customers whose names are already filed in an alphabetical card index; but instead of sending them out all together at one time, the intention may be to send them in batches spread over a week or two. It may further be determined to follow up the first letter with a succession of others, each going out at intervals of a week after the previous communication. The difficulty is to avoid the making out of fresh lists, or the disarrangement of the alphabetical order of the card index; for as different sections of the complete index must of necessity be dealt with at different times, the natural inclination would be to have either a supplementary list arranged in batches according to the dates on which the follow-up letters have to be sent, or to rearrange the original alphabetical list in some such way. It is necessary to know when each card is to have its next letter, and to see that the addressee gets it at the right date.

The Use of Metal Clips. The best method, and that which is usually followed is to have the numbers from 1 to 31, representing the days of the month, printed on the top of each card. Then when the first letter is sent out a little metal or enamelled clip is fastened on the card exactly over the date on which the next communication is to be posted. The clips, which are made for the purpose by various firms of office outfitters, can be bought quite cheaply. In this way all the clips on those cards which are to have a follow-up letter on a certain day are in the same relative positions, and form a line up the filing cabinet so that they can easily be turned up or picked out in order for addressing. The letters can be sent out day by day, and when a batch goes off the clips are moved forward to the date of the next communication.

The Card Index for the Wholesaler. If the card index is good in the various departments of a manufacturing business, it is almost a greater boon to the wholesaler as distinct from the manufacturer and the retailer. In these days, when the tendency is to direct trading between the two last mentioned, the wholesaler needs to have a perfect system of trading, office organisation, and records if he is to hold his own. The records of his buying, on the one hand, must be in detail and easily accessible for instant reference; while on the other hand, his customers' purchases and the terms on which they buy, with other useful information, must be equally full and easy of reference. The card index

is not only the most satisfactory system from the point of view of reference, but it is also the cheapest and least cumbersome.

The System for Recording Multiple Shop Trading. Then again so many wholesalers now run retail businesses that, to them, the card index system is all but indispensable. They have retail shops, not so much from choice as from necessity After supplying a retailer for some time and allowing him to run up a big account, it often happens that the man is unable to meet his liabilities, and the wholesaler then takes over his shop. In this way, and perhaps afterwards by purchase here and there, the wholesaler at last comes to own quite a number of retail shops in different parts of a town or district. Managers are appointed to each, and it is of course a necessity to keep detailed records of the goods sent to and the business done at each individual shop. Only by the card index can the necessary details be kept in such a way as to be accessible for all the purposes for which they are required. The same remarks apply to the ordinary multiple shop company.

The Card Index Ledger. An ingenious adaptation of the card index is to the keeping of account books, and the card index ledger is more and more coming into use, not only because of its convenience in that it gets over the old cumbersome task of periodically opening new ledgers when the old ones have become full, but also because it simplifies the work of bookkeeping and reduces the labour so much that in a large firm the services of at least one clerk can be dispensed with. As a matter of fact, accounts can be posted, checked, a trial balance taken, and statements made out ready for posting in about half the time required for similar work done from a book ledger. No separate index is required, for the set of cards is itself, of course, an index, being in alphabetical order. One great advantage is that, being on cards, the accounts can be divided up among a number of clerks for simultaneous handling, whereas only one man could work on a book ledger at one time. Closed accounts can be removed and placed in a separate file, so that the card ledger is never larger than it really need be, whereas the book ledger has of necessity to contain both open and closed accounts. The bulk, too, of the book ledger is ever so much greater than that of the cards with a corresponding number of accounts. Then, again, the card index ledger can, in the absence of any other list in the office, be used for the addressing of envelopes for posting form letters and circulars or price-lists.

Arguments Against the Card Ledger. One of the arguments sometimes advanced against the card index ledger is that, unlike a book ledger, it lays itself open to falsification. The book ledger, it is pointed out, cannot be altered without the change being detected. Anything scratched out must reveal itself sooner or later, whereas a card can easily be taken right out of the system. Where, however, proper supervision is exercised, there is little more fear of falsification with a card ledger than with a book. Errors can be detected just as easily in a card ledger as in a book, for the ledger does not stand alone; it has to agree with the other bookkeeping accounts. The proof of its advantage is that large firms are more and more coming to use it.

Economy of Time. The economy of time in the mere handling of a ledger arranged on the card system, as compared with the turning of pages and moving about of heavy volumes, is enormous, and this alone should recommend it, even if there were no other advantages. If ordinary care be exercised there is no fear of the cards being lost; for, except when they are actually being written upon, they are in the file drawers, secured there by the rod that runs through the perforations, and this rod can, if necessary, be rendered unremovable by a lock on the outside of the drawer. No unauthorised person will then be able to remove a card without the fact being detected. The beautiful elasticity of the card system is nowhere more appreciated than when it is adapted to ledger work.

The Loose Leaf Adaptation. The loose-leaf ledger is really only an adaptation of the card index. It is preferred by some to the card system, because it has more the appearance of the old-fashioned ledger, and does not seem such a drastic change from all the old-established methods. Further, because the leaves are held in by a mechanical arrangement that has a key, so that no leaves can be removed except by tearing, unless the holder of the key undoes the book, some people regard it as particularly safe. The same safety, as has already been explained, can be obtained in a card index ledger.

The Office "Tickler." A very useful adaptation of the card index system, which has quite superseded the old fashioned book diary in all up-to-date offices, is the reminder tray, or, as it is generally called in America and is now being described in this country, the "office tickler." This consists of a box with a hinged lid which can be closed down and locked so that any private information contained within may be secure from unauthorised eyes Inside the box or tray are forty-three guide cards, the twelve at the back representing the months of the year from January to December, and the thirty-one in front the days of the month. The names and numbers are inscribed on raised tabs. Letters and other documents requiring attention at some future time are then placed behind the cards with the dates on which they are to come up for consideration or final disposal. Matters for the current month are behind the cards with the days of the month inscribed on their tabs, and those for future months are behind the guide cards for those months.

Another useful adaptation of the card index system is to the pocket-book. By means of springs or clips in the back of a leather cover, and a number of detachable leaves, what is practically a portable card index will fit into the pocket.

CHARLES RAY

Focal Length. Law of Lenses. The Telescope and its Defects. Achromatic Lenses. The Lens in Use.

THE PROPERTIES OF LENSES

HAVING discussed the laws of refraction in general, and their application to spherical surfaces, we must now pass to a more practical matter—the application of the laws of refraction in the various kinds of lenses. Of the more abstract parts of this subject, however, we cannot make a very adequate study, but we must do so to a sufficient extent to enable us to understand the most wonderful of all optical instruments, which is the eye [see page 2014], and also certain other instruments of man's construction, such as the microscope and the telescope.

Lenses. The most familiar illustration of a lens is found in the pieces of glass which are put into spectacles. A lens may be made of glass or any other refracting medium. Glass is the most commonly employed. Much practical interest attaches, however, to the use of lenses made of other materials, which may behave otherwise than glass in relation to certain portions of the "ethereal keyboard."

A piece of glass bounded by two plane surfaces is not a lens; one surface, at least, of a lens must form part of a sphere, or must, at any rate, be curvilinear. We confine our attention to lenses which have a definite curvature. When the curved surface is curved outward or is convex, we have a convex or converging lens. When it is curved inward, or concave, we have a concave or diverging lens. We have already seen what is meant by a convergent and what by a divergent pencil of light, and our knowledge of the laws of refraction is now sufficient for us to understand why the convex lens is said to be converging and the concave lens diverging. One surface of the lens may be flat while the other is curved, thus giving us what is called a plano-convex, or a plano-concave lens; or a lens may have one surface convex and the other concave, as, for instance in the case of a watch-glass. The simplest, perhaps, are those lenses which are commonly used for spectacles, and which have both surfaces either convex or concave. Such lenses are called doubly convex and doubly concave, or *bi-convex* and *bi-concave*.

Focal Length. Each lens has an axis, and this, in the case of the bi-convex or bi-concave lens, is a straight line joining the centres of the two surfaces—that is, the centres of the circles of which the surfaces of the lens are parts. The reader must recall what has been said about mirrors in relation to a good many of the terms which are used of lenses. Thus a spherical mirror, like a lens, has an axis. Each also has a principal focus. When a pencil of parallel rays falls upon a convex lens in a direction parallel to its axis, its constituent rays converge after passing through the lens and meet one another at a point beyond. This point lies upon the axis of the lens, and is known as its *principal focus*. The statement as to the convergence of the rays is not completely true. It varies from the truth just as does the similar statement which we made concerning the principal focus of a spherical mirror.

But a bi-concave lens—or any concave lens—also has a principal focus. It is true that when a pencil of parallel rays falls upon such a lens they are caused to diverge, not converge. They will never meet one another. Nevertheless, if the lines of their new course be produced backward through the lens again, such lines will meet at a point upon the axis. In other words, the rays, after passing through the diverging lens, will *appear to diverge* from a point on the axis. The point is called the principal focus of the lens, and has the same significance as the principal focus of the convex lens, though it happens to lie on the opposite side. The distance between the lens and its principal focus, wherever that may be, is a very important fact about the lens, and is known as its *focal length*.

Having compared and contrasted convex and concave lenses, we note the simple fact that the divergent lens is thinnest at the middle, while the convergent lens is thickest at the middle. This is true of glass lenses in air, but these characters are interchanged when the refractive ratio is reversed, "as, for instance, when the lens is an air space surrounded by water." The laws of refraction explain this at once.

The Law of Lenses. Professor Tait summarises the whole matter in what he calls the following "excessively simple form": *A thin lens increases or diminishes by a definite quantity the convergence or divergence of all rays which pass through it.* "This quantity," he says, "is the divergence or convergence of rays falling on the lens from, or passing from it to, its principal focus. Or it is the convergence or divergence which the lens produces in parallel rays. Thus, if the distance of an object from a convex lens is twice the focal length of the lens, the image is formed at the same distance from the lens, and is equal in size to the object.".

The reason why we have to say "a thin lens" is evident if we consider what happens in refraction at parallel surfaces. We know that when light passes through a pane of glass it emerges, not in its original direction, but parallel to it. In the case of a lens of any considerable thickness, this would introduce a new complication, but as a rule the thickness of a lens is very small relatively to its focal length, and so we may assume for practical purposes that rays which pass through the optical centre of the lens are continued in the

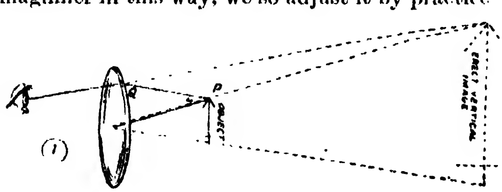
same straight line. This *optical centre* is defined as a point found in every lens, lying in its principal axis, and such that every ray of light passing through it emerges in a direction parallel to its original direction. In the case of thin lenses, such rays are practically continued in the same straight line.

The phrase *conjugate foci* describes two points upon the principal axis of a spherical mirror so related that the rays upon either are brought to a focus at the other. Similarly, a pencil from any point near the axis of a lens converges on the other side of the lens to another point which is also near the axis. If the lens be concave, such a pencil is treated so that it appears to diverge from another point, similarly near the axis, but in this case on the same side of the lens. Such pairs of points in either case are called *conjugate foci*, and have the relation that the rays of a pencil from either will pass through the other in the case of the convex lens, or will appear to pass through the other in the case of the concave lens.

Convex Lenses and their Images. Anyone who has ever possessed a convex lens of the kind used in spectacles or as simple microscopes, must have observed certain facts for himself which may here be briefly stated. Two kinds of images are produced by such a lens. The one is real and the other virtual. The one called *real* is so because the refracted rays have actually passed through the point which they appear to pass through. The virtual image is so called because the refracted rays do not actually pass through the point, but merely appear to have diverged from it, as can be seen if the rays are produced backwards. In either case the size of the image varies directly as its distance from the centre of the lens. When we use such a glass as this as a simple microscope, we place the lens close to the body to be studied, and we obtain an upright image of the body, which is *virtual*. The body in such cases must be nearer to the lens than its principal focus. It is so near that the rays from it diverge greatly—so much so that the lens, though a converging lens, is not able to destroy the divergence, but merely to lessen it.

Says Professor Tait: "In using a hand magnifier in this way, we so adjust it by practice

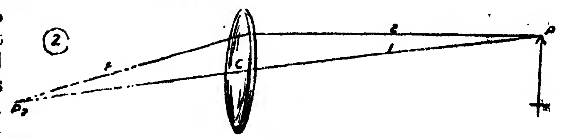
(1)



that the enlarged image appears to be formed at the distance from the eye at which vision is most distinct. It is obvious that the amount of magnification must then be greater as the focal length of the lens is less." This, of course, means that the most "bulgy" lens is the most powerful magnifier. The accompanying diagram—note what happens to the divergent ray PQ—shows what happens in the production of a virtual erect image by a convex lens used in the fashion we have described—the point being that the object, the image of which is formed, lies nearer to the lens than its principal focus.

The Second Kind of Image. But when we hold up such a simple microscope to the eye, we obtain a very small inverted image of distant

(2)



objects. The reader should see this for himself with the aid of his glasses, if he be long-sighted, or by means of a simple mircoscope, if he possess one, or by means of one of the object glasses from the eyepiece of his microscope. Convex lenses are used for this purpose in various ways, as, for instance, in the object glass of a telescope, and in the familiar scientific instrument which is called the *camera obscura*.

The accompanying diagram shows the conditions under which this real inverted image is formed. In order to find the position of the image of any point formed by a lens, such as the point P at the head of the arrow in our diagrams, we should begin by drawing two rays. The first is one which passes through the centre of the lens and has its course unchanged. The second is the ray which passes from the point P parallel to the axis of the lens, and, being parallel, is therefore refracted so as to pass through the principal focus of the lens. In the accompanying diagram we have marked these rays 1 and 2. The point at which these rays coincide is the point where the image of P will be formed—that is, P 2 on the diagram. Once we have obtained the position of P we can then construct the remainder of the image, and the reader may be left to complete the diagram.

The Microscope and Telescope. These facts are already sufficient to enable us to understand the principles of the ordinary astronomical telescope and the ordinary compound microscope. Thus, the fundamental part of the compound microscope is merely the simple microscope or convex lens which constitutes the part of the instrument near the object and is known as the *objective*. But let us begin with the telescope, and, first of all, a few words as to its history.

Here we cannot do better than quote from the authoritative life of Galileo, by J. J. Fahie. The telescope was invented accidentally in Holland, in October, 1608, thus: "As the story goes, an apprentice playing with spectacle lenses in the shop of one Hans Lipperhey, an optician of Middelburg, noticed that by holding two of them in a certain position a large and inverted view of objects was obtained. On hearing of this, the master fixed two glasses in a tube so that the weathercock on a neighbouring church spire could be seen apparently nearer and upside down." This toy was shown in his window, where one day it was seen by a noble-

man, purchased, and presented to a prince. Lipperhey petitioned what corresponded to our Parliament for a patent right, and they suggested that he should make the instrument so that one could look through it with both eyes, which he did. Their idea seems to have been that the instrument would be useful in war. There are two other claimants, also Dutchmen; but the interesting fact is that the news of the discovery, *but no more*, reached Galileo in the next year.

Galileo's Claims. The following is a precise quotation of a letter written by the great genius to his brother in law "You must know then, that about two months ago" [*i.e.*, about June, 1609], "a report was spread here that in Flanders a spyglass had been presented to Prince Maurice, so ingeniously constructed that

DIAGRAM SHOWING HOW A MAGNIFYING GLASS MAKES THINGS APPEAR BIGGER

it made the most distant objects appear quite near so that a man could be seen quite plainly at a distance of two miles This result seemed to me so extraordinary that it set me thinking and as it appeared to me that it depended upon the laws of perspective I reflected on the manner of constructing it and was at length so entirely successful that I made a spyglass which far surpasses the report of the Flanders one As the news had reached Venice that I had made such an instrument, six days ago I was summoned before their Highnesses the Signoria, and exhibited it to them, to the astonishment of the whole Senate Many of the nobles and senators, although of a great age, mounted more than once to the top of the highest church tower in Venice in order to see sails and the shipping that were so far off that it was two hours before they were seen, without my spyglass, steering full sail into the harbour, for the effect of my instrument is such that it makes an object 50 miles off appear as large as if it were only five."

Galileo's Method. Subsequently, in the year 1623, Galileo defends his right to be considered an independent inventor of the telescope. The point is worth insisting on, and we will quote, from a book of his, a few of the more interesting and instructive sentences "With this simple fact" [the report about the Dutchman], "I returned to Padua and reflecting on the problem I found the solution on the first night after my arrival. In the next six days I made a more perfect instrument. It may be said that the certitude of the existence of such a glass aided me, and that without this knowledge I would never have succeeded. To this I reply that without the information my thoughts may never have been directed that way, but that such information made the act of invention easier to me, I deny, and I say more—to find the solution of a definite problem requires a greater effort of genius than to resolve one not specified, for in the latter case hazard, chance, may play the greater part, while in the former, all is the work of the reasoning and intelligent mind I on the simple information of the effect obtained, discovered the same instrument, not by chance but by way of pure reasoning

Here," he continues, "are the steps the artifice of the instrument depends either on one glass or on several It cannot depend on one, for that must be either convex or concave, or plain The last form neither augments nor diminishes visible objects, the concave diminishes them, the convex increases them, but both show them blurred and indistinct Passing, then, to the combination of two glasses, and knowing that glasses with plain surfaces change nothing, I concluded that the effect could not be produced by combining a plain glass with a convex or a concave one, I was thus left with the two other kinds of glasses, and after a few experiments I saw how the effect sought could be produced Such was the march of my discovery, in which I was not assisted in any way by the knowledge that the conclusion at which I aimed was a verity"

There are no details about the first telescope; but the second was only as strong as a moderately powerful pair of opera glasses An opera glass is simply a pair of Galilean telescopes fixed together.

Images Formed by Concave Lenses. But before we can go any further, we must discuss the image formed by a concave lens, for it was such a lens that Galileo used as his eyepiece, and these lenses are still used as the eyepieces of opera glasses. A concave lens, such as short-sighted people use in their spectacles, yields an *upright* image which is *virtual*. Let the reader draw for himself a concave lens with a small arrow at some little distance, as in the previous diagrams. Let him then draw, as in the previous case, the two rays, one passing through the optical centre of the lens, and the other parallel to the principal axis of the lens. As in the previous case, the image of any point of the object from which we start, such as the image of the tip of the arrow, will be found at the intersection of these two rays. The ray parallel to the principal axis, when passing through the lens, is refracted in the direction of the thicker part of the lens, as the rule invariably is. The line of its new course must now be produced backwards until it reaches the axis of the lens at the point which is, of course, the principal focus. When the figure is completed, the reader will see why the image formed is smaller and erect, and why it is said to be virtual.

The great advantage of Galileo's telescope was —and is, for the user of opera glasses—that one obtains an erect image, though only two lenses are used.. The parallel pencil of light coming through the object glass, which is convex, is received by the concave eyepiece before it reaches its focus, and as the focuses of the two glasses coincide, the rays emerge parallel. Galileo went rapidly on from strength to strength. In a few days he made third and fourth telescopes, the latter making the moon "appear about twenty times nearer, and four hundred times larger than when seen by the unaided eye." He soon found that he had to fix his telescope on a support, in order to obviate shaking. He ground his own lenses.

It was with his fifth telescope, made in January, 1610, and showing objects more than thirty times nearer, that he not merely continued his study of the moon, but made several very important astronomical discoveries [see page 381]. The broken object glass of this celebrated telescope, the most epoch-making scientific instrument in history, is now preserved in the Tribuna di Galileo, in Florence.

An Invention and a Revolution. We have thought it worth while briefly to remark on the immediate results of the invention of the telescope, not merely because they illustrate the diligence of Galileo, but because they show the extraordinary consequences which may ensue to science by the invention of a new instrument—in this case nothing more than a concave lens and a convex lens fixed opposite one another in a tube. The most amazing fact of all, perhaps, is that Galileo never got beyond a telescope magnifying a little more than a thousand times, yet his results sufficed to revolutionise the most magnificent of the sciences, and to alter man's conception of the place of his home in the universe.

As we have hinted, Galilean telescopes are now used only in opera glasses. The ordinary astronomical telescope depends for its understanding merely upon a knowledge of the properties of convex lenses; the concave lens is not employed at all. In describing it, we cannot do better than quote part of the description given by Professor Tait: "The object glass furnishes an inverted but real image of a distant body *within our reach*. We can therefore place the eyepiece (just like a simple microscope) so as to form a virtual magnified image of this real image treated as an object. It is still, of course, inverted." This inversion of the image, in the case of an instrument used for looking at the heavenly bodies, is, as a rule, of practically no consequence. The distance between the two lenses in the ordinary astronomical telescope is the sum of their focal lengths. In the Galilean telescope it is the difference of their focal lengths.

The considerable advance in the use of the telescope, which this instrument represents, is largely due to another astronomer, Kepler, who became possessed of one of Galileo's instruments, and then designed a telescope consisting of two convex lenses—the rays converged by the first of which are allowed, as we have seen, to come to a focus before they reach the eyeglass.

Magnifying Power of a Telescope. We cannot go at length into the manner in which the following statement is to be proved, but must simply state it. The magnifying power of a telescope may be estimated by the ratio of the focal length of the object glass to the focal length of the eyepiece. It is of interest to note the rough fashion in which the pioneer estimated the power of his telescopes.

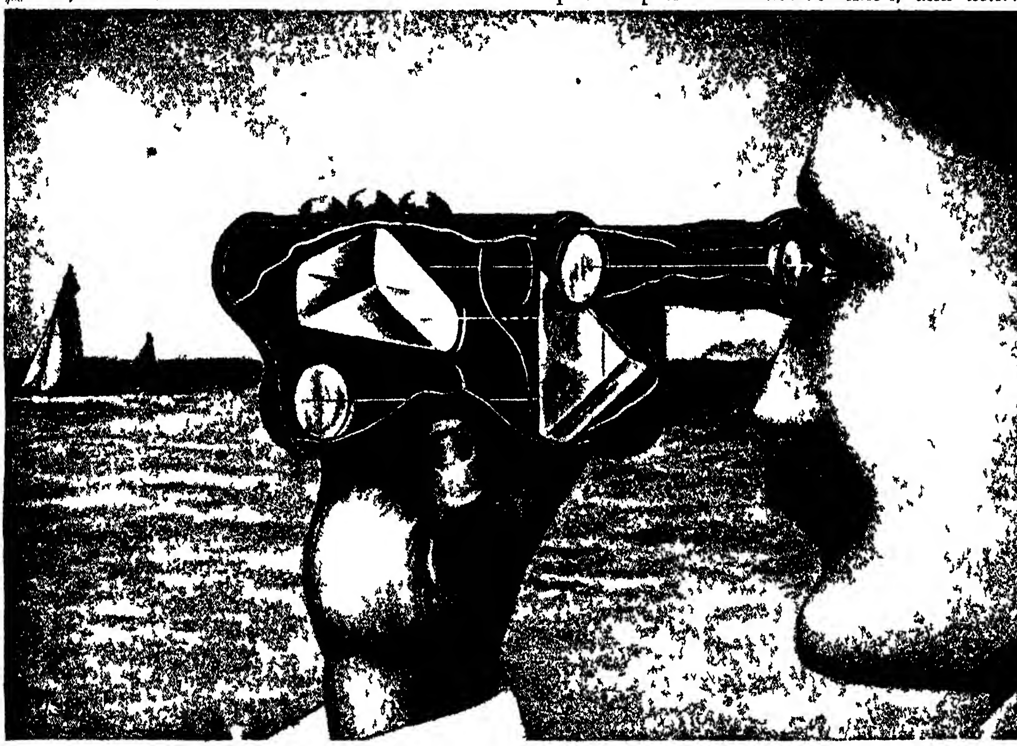
"Place," he says, "upon a wall, at a certain distance, two unequal discs, one of which you will observe with the telescope and the other with the naked eye. If the disc seen through the telescope appear equal to the other, the magnifying power of the instrument is in the proportion of the two discs. If they do not appear equal, the 'other' disc must be enlarged or diminished until they do, and then the magnifying power will be as before, in the proportion of the discs."

We have already made the acquaintance of the simple microscope—which is indeed simple; and, fortunately, our study of the astronomical telescope suffices for the understanding of the principle of the compound microscope which, in its simplest form, is one and the same instrument. Says Professor Tait: "The only difference is that the object, being at hand, can be placed near to the object glass (still, however, beyond its principal focus), so that the real image formed is already considerably larger than the object, and is then still further magnified by the eyeglass."

The Defects of the Telescope. The telescope and microscope as used today are not such simple affairs as this, but here, at any rate, we describe their principles. Such simple instruments have certain very decided defects, and in order to obviate these further complications are introduced. Let us see what these defects are.

When we were discussing spherical mirrors we made the acquaintance of spherical aberration We saw that incident rays, somewhat remote from the pole of the mirror, are not reflected so as to pass through the principal focus, but only so as to pass near it Similarly also in lenses, the rays which strike them near the edge are not brought properly to the same focus as those which strike the lens near its centre Hence the image will be blurred, and something has to be done in order to counteract this defect

In the case of mirrors we saw that the difficulty was got over by substituting for a mirror the section of which is an arc of a circle, a parabolic mirror, the section of which is that curve known



THE USE OF PRISMS IN A FIELD GLASS, SHOWING THE COURSE OF THE LIGHT RAYS
This explanatory diagram was prepared with the assistance of Messrs D ll n l the well kn wn m k rs of optical instruments

as a *parabola* Similarly, we may alter the curvature of a lens, but more commonly we employ combinations of lenses which compensate for each other's defects Or, again, we may adopt, as is very often done, the simplest possible device, which is to use a circular screen or diaphragm that simply cuts off all the light falling near the edge of the lens, while permitting the light which falls upon its more central part to pass through The use of a diaphragm for this purpose is of very special interest, because every one of us employs this means in his own eye when looking at a near object Spherical aberration, then, is one of the difficulties which the modern optical instrument has to remedy

The Case of a Single Lens. But there is yet another difficulty, which is called *chromatic aberration* Remember that the light which is commonly employed in the use of the telescope or microscope is mixed light, consisting of rays of a number of different wave lengths The difficulty that arises has already been alluded to in a paragraph in the last chapter, called the *correction of dispersion* As we have seen, Newton concluded from his experiments that the amount of dispersion is, for all substances, proportional to that of the refraction so that to annul the dispersion by any system of prisms would be also to annul the refraction

Let us now consider the case of a single lens In any given lens the refractive index varies according to the colour or wave length of the light Now the focal length of a lens entirely depends upon its refractive index, and hence though we have talked of the focal length of a lens as if it were an invariable quantity, the actual fact is that *it is a different quantity for every wave length of the light that falls upon it* One and the same lens has different focal lengths for each constituent of the mixed or white light that may fall upon it The rays at the violet end of the spectrum are more refracted than those at the other end —in other words, they are brought to a focus first, while the red rays are brought to a focus last Hence it is that at different distances we get different rings of colour round the image of any object looked at In any kind of delicate work this is a very serious defect, and this it is that we mean by chromatic aberration—a necessary defect of all single lenses

Newton believed that dispersion and refraction are proportional, and therefore that no com

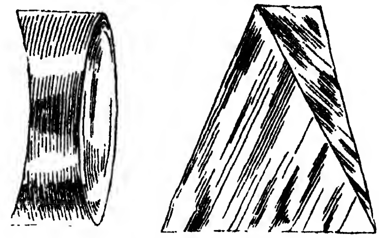
bination of lenses could ever remedy chromatic aberration without also doing away with the refraction and making them useless. But the mistakes of a great man are far more profitable than the correct opinions of little men. The consequence for Newton was merely that he set to work and invented another kind of telescope altogether.

Newton's Telescope. We shall be treating the subject in the proper chronological order if we consider this new kind of telescope before we go on to show how, after Newton's death, there was discovered a means of obviating chromatic aberration in the manner which he had erroneously pronounced to be impossible.

Newton knew that, whereas light of various colours is variously refracted, it is not variously reflected. If a mirror be used we do not therefore have the difficulty of chromatic aberration which occurs in the case of a lens. When white light is reflected by a mirror it remains white, without any coloured rings. Therefore Newton employed a curved mirror made of highly burnished metal, and brought his light to a focus by it instead of by a lens. The difficulty arises, however, that if we are to make any observations in such a case, we should have to stand in our own light. Therefore a plane mirror has to be used, and placed at right angles to the axis of the curved mirror, so that it reflects at right angles the light which has already been reflected from the curved mirror. There is thus obtained an image, just as by the objective of an ordinary telescope, and this image is looked at and magnified by an eyepiece, just as in the previous case. The interesting points for the student to remember are the fact that chromatic aberration occurs with lenses but not with mirrors, Newton's belief that no combination of lenses could correct chromatic aberration, and Newton's consequent invention of the telescope which goes by his name.

The reader will hardly need telling that the term "achromatism" is derived from two Greek words meaning *not* and *colour*. Now, Newton notwithstanding, it is possible to correct dispersion, while still allowing some refraction to remain, by means of prisms made of different angles. For instance, the dispersion caused by a comparatively wide prism of glass may be corrected by a much narrower prism containing bisulphide of carbon, while the refraction is not entirely disposed of. Similarly, glass will correct the dispersion of water (the prism of the latter being the wider), though some refraction still remains. It has been supposed that Newton's failure to get this result from practically the very same experiment was due to his use, in his water prisms, of lead, which increases the dispersion of water.

Discovery of the Achromatic Lens. The famous name in the history of this subject is that of Dollond, who performed Newton's experiment over again, but obtained a different result. He discovered that, as flint glass causes a greater dispersion, in proportion to its refractive power, than crown glass, achromatic or colourless magnified images can be obtained by using a combination of these two materials—a bi-concave lens of flint glass with a bi-convex lens of crown glass. Each of these had a very considerable aberration, but, by "trial and error," he was enabled to adjust them so that



their aberrations were equal, and, as their refractions were opposite, the two aberrations neutralised one another.

The explanation of the achromatic lens of Dollond may be otherwise stated. As flint glass has more dispersive power than crown glass, a weaker flint glass lens will cause as much dispersion as a stronger crown glass lens. The two lenses neutralise one another on the score of dispersion, but the balance of strength on the part of the crown glass lens remains. Hence, the result is white light, which converges as if it had come from a single convex lens equal in strength to the actual convex lens of crown glass *minus* the actual concave lens of flint glass. Such achromatic systems of lenses are always, nowadays, employed in any but the cheapest optical instruments.

Similarly, of course, we can obtain achromatic prisms. These are made of flint and crown glass, similarly combined. A narrow prism of flint glass corrects the dispersion of a much wider prism of crown glass, but though lessening its refraction, does not altogether dispose of it. Such a combination, therefore, is equivalent to a single prism, equal to the difference between the two actual prisms, but produces an achromatic or colourless result. The accompanying diagram shows the achromatic lens and the achromatic prism.

Cameras. The ordinary camera is fitted with a lens or system of lenses which are, in effect, convex, and which form inverted images. Further, there is another kind of optical instrument which is usually employed in a dark room, and which therefore goes by the Italian name for such a room—*camera obscura.* Here light is reflected from a mirror or a prism through a right angle, this being placed in the roof of a room. On its downward path the light passes through a converging lens, and is focussed on a white table or a table covered with white paper. If the mirror in the roof can be rotated upon a vertical axis, it will admit light from any part of the surrounding country or town. Like the kinematograph, it gives, of course, a living picture, but it is the perfect living picture which our own eyes directly afford us, free from all jerks, vibrations, and other defects.

C. W. SALEEBY

Varieties of Cement. Natural and Artificial Cements. Dry and Wet Processes of Manufacture. The Raw Materials and their Preparation.

CEMENT MANUFACTURE

Change of Lime to Cement. In speaking of limes, it has been shown that, owing to the presence of small quantities of clay in the original limestones, the resulting lime, known as hydraulic lime, sets to a hard mass in air, and even under water. The hardening of hydraulic limes is brought about by a chemical process quite different from the induration of mortar. In the latter case the change is due to the conversion of calcium hydroxide into calcium carbonate, but in the case of hydraulic limes other substances play a part—*viz.*, the silica and alumina of the clayey matters in admixture with this type of lime. These substances, by mutual chemical reaction, form silicates and aluminates of lime after the mortar has set.

If the temperature of the kiln be higher, the silica, in the course of lime burning, undergoes some sort of change; it is converted into a more soluble condition than before, and is in a much better position to react with the lime to form silicates when worked up with water. Consequently, a much harder-setting material is produced than in the case of hydraulic limes. The quick setting cements, of which Roman cement is a type, no longer possess the characteristics of lime when mixed with water; they do not slake and fall to powder.

Portland Cement. Lastly, if we carry the burning to such a stage as to fuse, vitrify, or clinker the mass, we obtain a product resembling Portland cement, and differing markedly from all the hydraulic limes and quick-setting cements with which we have yet dealt. The older cement makers realised the radical changes produced by clinkering. When preparing such cements as Roman cement, they were careful to look over and cast aside as useless any clinkered portions; yet it is a curious fact that the necessity of raising the temperature sufficiently high to fuse or clinker the mass is not mentioned by Aspdin in the original patent for the manufacture of Portland cement. Subsequent makers soon realised that they must aim at producing these clinkered lumps which they had formerly thrown on to the waste heap. In consequence of the high temperature in a cement kiln, the silica and alumina present in the clay react with the lime in the process of burning, to produce substances known as silicates and aluminates of calcium. These substances are able to combine with water to form hydrated silicates, which are hard rock-like substances.

The cement is dense and slow setting, and its power of setting and hardening under water is brought about by hydration of the silicates and aluminates—that is to say, the combination of these substances with water. It is now generally agreed that the setting of the cement is due to the hydration of the calcium aluminate, while the subsequent hardening is brought about by the calcium silicate.

It is an easy step to pass from a natural limestone containing clayey matter to an artificial mixture of limestone and clay which form the ingredients in the manufacture of Portland cement.

Kindred Processes. We strongly advise the student to make himself thoroughly acquainted with the course on LIMES before tackling CEMENTS.

Limestone and chalk are the raw materials in both cases, and we have not seen the necessity of repeating under CEMENTS what we have already fully described under LIMES. Much of the matter described in the BRICKMAKING course will also be found of use here. Thus, we described in that section the Hoffmann kiln, so much used in burning bricks, but also adapted for burning lime and cement.

It is also instructive to contrast the grinding machinery used in the brickmaking and cement industries. The principle of the wash-mill is the same in both, but when we come to grinding hard materials, such as limestone or cement clinker, we require a different type of apparatus altogether.

Cement has been described as a dry and dusty subject. A visit to a cement works will convince one of the dust. We shall, however, do our best to present the matter in as readable a form as possible. We should try to realise its enormous importance. Cement is coming into use more and more, not only in building the foundations of our wharves, reservoirs, waterworks, etc., but in constructive work, such as Portland cement concrete, ferro-concrete, reinforced concrete, and artificial stone. The consumption abroad, especially in the United States, is much higher than in this country, where it does not exceed one hundredweight per head.

Cement used by Smeaton and Others. Before the discovery of Portland cement there were in use a number of natural cements similar to the hydraulic limes, which are nowadays mostly replaced by the cheaper and more efficient Portland cement.

In the volcanic district in the neighbourhood of Naples there is found a sort of volcanic ash termed pozzolana. This substance contains approximately 50 parts of silica, 16 of alumina, 12 of oxide of iron, and 9 of lime. By mixing 30 parts of lime with 70 parts of pozzolana, an excellent cement is produced, resistant to the action of water. It was used in conjunction with lias lime by Smeaton for building the old Eddystone lighthouse.

It will be seen that pozzolana serves to replace the sand in mortar, but that it differs from the latter in that it is capable of reacting with the lime to form a water-resistant material.

Similar cements have been made from so-called Trass, found in the Rhine district, and Santorin earth, from an island of that name in the Greek Archipelago. Ground brick may also replace sand, and its action is similar to that of the substance just mentioned.

Natural Cements. Roman cement is a quick-setting cement, closely allied to hydraulic lime. It is a natural cement, made by calcining certain rounded lumps of stone found in the neighbourhood of the Isle of Sheppey. These stones, termed "septaria" nodules, lie embedded in the marl, just like flint in chalk, and owe their origin to similar natural processes. [See GEOLOGY.] These nodules contain, on an average, 60 to 70 parts of calcium carbonate, 18 to 20 parts of silica, and 6 to 10 parts of alumina. They are heated in conical kilns, similar to lime-kilns, and the burning is carried far enough to drive off all the carbonic acid from the mass, but not so far as to clinker it. The lumps are then finely ground. For use it is well mixed with about one-third its volume of water. It sets in from five to fifteen minutes, and under water in less than an hour.

Another similar cement, known as Medina cement, is made from a stone found in the Isle of Wight. Both these cements set rapidly under water, and where a very rapid setting cement is required, they thus possess certain advantages over Portland cement.

History of Cement. It may be truly said that Portland cement was the invention of an Englishman, and that England is the cradle of the industry. Previous to this we have the discovery of hydraulic mortars by Smeaton, who used them with such success in building the old Eddystone lighthouse; while Vicat, the Frenchman, at the beginning of the last century, was probably the first to use an artificial mixture of clay and chalk in the place of clayey limestones, as found in the natural state. The actual discovery of Portland cement we owe to Joseph Aspdin, a bricklayer in Leeds, who took out his patent on October 21st, 1824. He called his cement after the celebrated building-stone from the Island of Portland.

Aspdin's cement was originally made at Wakefield, and had already attained some notoriety before it began to be manufactured in the South of England. Here it eventually assumed enormous proportions. At the time of the Great Exhibition, in 1851, it had already attained a foothold, and begun to replace the old Roman cement. A little previous to this its manufacture was taken up by Messrs. White & Co., of Swanscombe, on the Thames estuary, and afterwards by an increasing number of firms in the same neighbourhood, until eventually the greater part of the world's production originated from Kent works situated on the lower reaches of the Thames and Medway. This is, alas! no longer the case, although more cement is still made here than in any other part of England.

Manufacture of Portland Cement. The actual manufacture falls into three distinct operations, *viz.*:

1. The preparation of the raw materials.
2. The burning of the cement clinker.
3. The crushing and grinding of the clinker to form the finished article.

The General Treatment. It goes without saying that different materials will call for different methods of preparation, but the object will always be the same—*viz.*, intimate mixing of the different constituents in a finally divided state.

In the early history of cement manufacture, as we have already explained, the raw materials were invariably soft chalk and river mud. These could be best and most safely mixed in the wet state. Both contained a considerable amount of water in the natural condition in which they were found, and were soft enough to be washed out easily by a further quantity of water, leaving stones, flints, and other impurities behind. Later on, as the demand for cement increased, it was found that equally good cement could be made from a great variety of other materials besides chalk and river mud, such as marl, different kinds of limestone, whether hard or soft, in conjunction with different sorts of clay, either gault clay or the various forms of shale and slate. Any of these raw materials can be used, provided that the chemical composition of the ingredients at hand makes it possible to produce a mixture of the proper composition, and further assuming that the raw materials do not contain dangerous constituents—such as magnesia, sulphuric acid, etc.—in such quantities as to affect the soundness and quality of the cement.

We may here mention incidentally that of late years another raw material has been largely used in the manufacture of Portland cement—in this case, not a natural stone, but a waste product—*viz.*, the slag from blast furnaces, which contains the three necessary ingredients—lime, alumina, and silica.

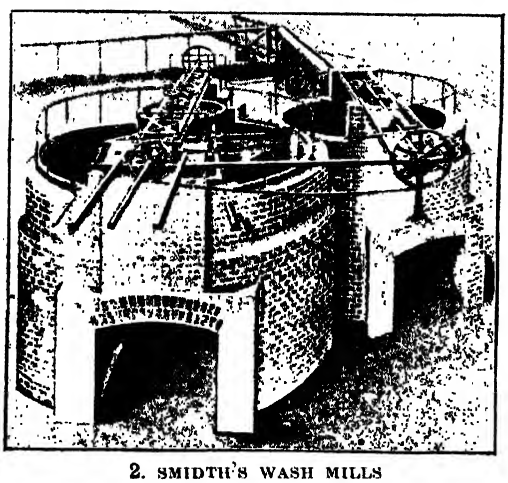
The difference in the nature of the raw materials as they are received in the factory naturally leads to different methods of treatment, and these are technically known as the different processes. Strictly speaking, there are a very great number of these, but in a general way they may all be classed under two heads—namely, the *wet* and *dry* processes. All the others can be considered as falling more or less under one or other of these processes, or a combination of the two.

The Wet Process. This method consists in washing the raw materials together into a thinner or thicker "slurry," and is, as a rule, only used in those cases where the raw materials are of such a soft nature that washing can be done by a simple apparatus called a wash mill, assisted afterwards by a grinding apparatus to reduce the slurry to a high state of subdivision. It may, however, be mentioned here that the wet process has also been used with harder materials, requiring "edge-runner" mills to disintegrate them.

In the early days of cement manufacture the wet process was exclusively employed, and a very considerable amount of water was used for washing the materials. The slurry was consequently very thin, and could be led through a system of channels, in which the coarse particles settled to the bottom, and were thus eliminated; whereas the fine, thin slurry was run into large settling "backs," or reservoirs. Here the cement material would gradually settle, and the water could be got rid of, partly by draining it off and partly by evaporation, so that after two or three months the cement raw material, or slurry, had assumed the form of thick sludge, somewhat of the consistency of soft-soap, and in this shape was taken to the kilns to be burnt.

Improvements in the Wet Process. Nowadays a more direct process has been very generally adopted, especially in England, by which the quantity of water required is greatly reduced, and a thick slurry formed, which can be pumped direct to the drying floors, so constructed as to utilise the waste heat from the kilns. The original system is known as "the Goreham process."

Making Slurry. In either case the apparatus usually adopted for reducing and mixing the materials is the wash mill [1]. This consists of a brick-built basin of circular or octagonal shape, about 6 ft. deep and 12 to 20 ft. across, partly sunk into the ground, with a brick-built pier or block of masonry (A) in the centre supporting the machinery. This consists of a driving gear (B) attached to a vertical shaft (C), supported at the lower end by the pier, and provided with a number of horizontal arms, termed "channel" or "angle" irons (DD). Cross harrows (EE), with renewable steel tines

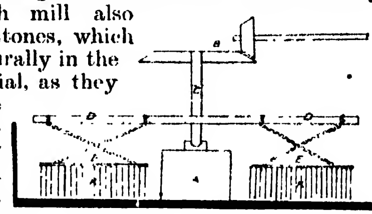


2. SMIDTH'S WASH MILLS

or metal bars (KK), are suspended by chains from the arms. The cross is made to revolve by the driving gear, and drags the harrows round in the mixture of raw material and water. By the tearing and rubbing action the raw lumps are gradually disintegrated and washed into slurry. To ensure regularity of working, means must be provided to regulate the quantity of water added, so that for a given weight of raw material tipped into the basin a corresponding quantity of water is admitted.

The slurry, as a rule, leaves the wash mill through a grating let into one of the sides of the mill, and the openings in this grating will, to a certain extent, ensure that the slurry possesses a uniform degree of fineness when it leaves the mill.

Removing Stones from the Slurry. The wash mill also removes stones, which occur naturally in the raw material, as they will not be disintegrated by the action of the mill. These stones—



1. SECTION OF A WASH MILL

such as flints from chalk, etc.—collect at the bottom of the basin, and can be periodically dug out and removed.

As the stones continually accumulate while the operation is in progress, the harrows must be gradually lifted up by shortening the chains by which they are suspended, so as not to work with the tines in the accumulation of stones, otherwise there would be undue friction and considerable waste of power.

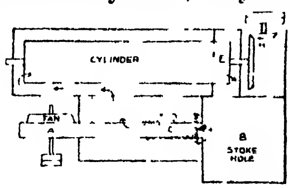
The wash mill must, of course, be stopped to lift the harrows and to remove the stones.

An improved form is Smidth's mill [2], which is so arranged that the whole cross with the harrows suspended from it can be gradually lifted by turning a hand wheel. In the illustration two wash mills are shown. They are, further, built on arches entirely above ground, and at such a height that tip-waggons can go in under them. In the bottom there are openings provided with doors, which open downwards. By opening these, the stones which have accumulated in the wash mill can be emptied out with the assistance of the harrows, which should be lowered to such an extent as to scrape the stones to the openings. In this way the wash mill can be cleaned out in a few minutes instead of being put out of action for several hours. Fig. 2 illustrates this type of wash mill. The tops of the horizontal revolving arms can just be seen.

Chalk Lumps in Slurry. In modern practice, when the slurry is thick, it is necessary to grind it in order to get it fine enough. As it comes from the wash mill it may contain "nibs," or small lumps of chalk, and if these are allowed to remain without being reduced and thoroughly mixed with the clay, they will be converted into free lime in the process of burning the clinker, and the resulting cement will be unsound. With few exceptions, the only machines which have been used for grinding the slurry are millstones of the ordinary type, the slurry being pumped in through an opening in the centre of the top stone, and in many

factories several consecutive passages through the stone being deemed necessary to get the slurry fine enough. Of late years, however, the tube mill, adapted for wet grinding, has come much into favour. This mill is practically the same as the tube mill for dry grinding, which will be described later on.

The Dry Process. This process can be used for practically all materials, but is most often used with those which are too hard to be treated in the wash-mill. The raw materials are ground and mixed in a dry state; they are, with a very few exceptions, artificially dried before grinding.



3. DRYING DRUM

Drying Raw Materials. Unless the raw materials are absolutely dry as they are brought into the factory, an artificial drying is necessary, because it is practically impossible to grind a material containing moisture to a really fine powder. Even a very small quantity of water will give trouble by condensing in places where it comes into contact with cold metal, and will form a sludge with the dust, which will gradually accumulate and clog the apparatus.

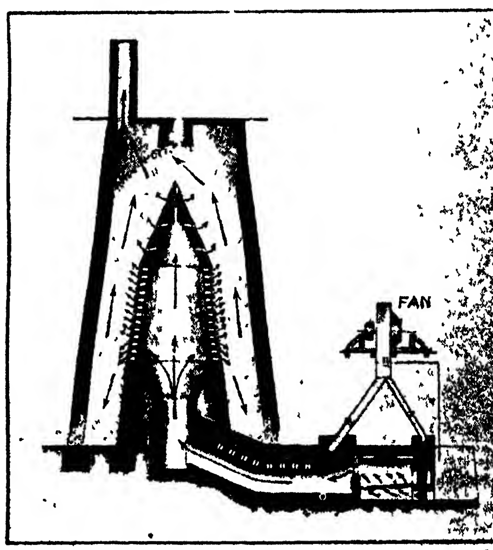
The drying has, in many cases, been done on drying flats—that is to say, floors often covered with iron plates and heated from below. [See illustration of Anderson kiln and chambers.]

In modern practice there are, however, only two methods commonly employed on a large scale.

The Drying Drum. The first of these is the drying drum, consisting of a cylinder heated from inside or outside, or on both sides, and through which the material slowly passes. The drying drum can either be placed at an angle to induce the material to pass down it, or it can be provided with ribs or projecting plates placed along a screw-line inside, so that the interior somewhat resembles an Archimedian screw with the centre cut away. The simplest form of drying drum is one used in conjunction with the rotary kiln. It forms a continuation of the kiln itself, and is heated in a simple manner by the waste heat from the kiln passing through the dryer on its way to the chimney. Besides this form of dryer there is an endless variety of designs, some consisting of only one cylinder, and some of two or more inside each other. Others are divided longitudinally into cells, to increase the drying capacity. They either utilise the waste heat in some way or other, or are provided with a special furnace fitted with an artificial draught produced by means of a blast fan.

As an example of this type of dryer, we give an illustration [3]. In plant of this construction, the stokehole B is so arranged as to be under air pressure, and the air forced in by a large fan (A). From the stokehole the blast passes through the furnace C, in the direction indicated by the arrows, and forces the hot air in the direction as shown, passing first outside the drying drum and then back through the inside, finally leaving through a chimney placed above the opposite end of the drum, at E. The drum revolves, driven by the gearing shown at H.

Drying Kilns. The other form of dryer referred to above is the drying kiln. This, again, can be built in many different forms. One of the best, especially in respect to the economical results obtained, is the Smidth drying-tower. We give a section illustrating the action of this dryer [4]. In 5 is shown a typical drying-tower, one of many in use in English and foreign cement works. The drying tower is a vertical brick-built kiln of slightly conical shape. In the interior is a brick-built dome with perforated sides, connected at the bottom with a furnace with smokeless combustion—that is to say, producing heated gases free from smoke to avoid contamination of the raw material in the kiln. The furnace is operated under forced draft with air driven in by a fan. Cold air is also admitted by another channel and mixed with the hot air from the furnace as it passes on its way to the interior of the tower. The blast from the fan forces the hot air in through the dome, and distributes it evenly throughout the charge in the kiln, which fills the space between the dome and the brickwork. Around the base of the latter are a number of doors, through which the dried material falls by gravity, and the tower is kept constantly full with material put in at the top. A chimney or flue leads from a point

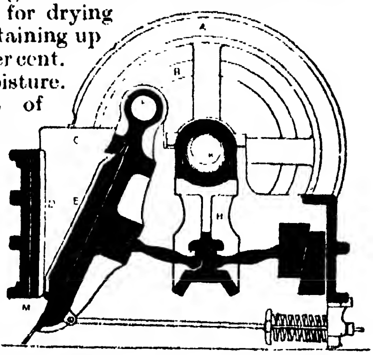


4. SECTION OF DRYING TOWER

in the upper part, and the spent air laden with moisture escapes through it.

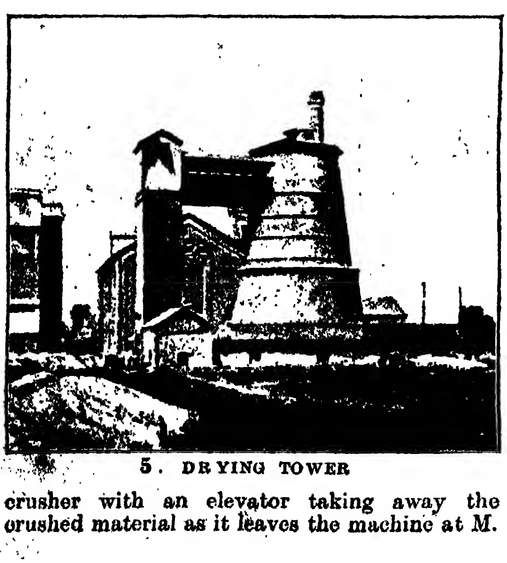
A drying tower of this type can be built on a large scale, and has a very considerable output. It is quite easy to build a tower to heat 200 tons of raw material every twenty-four hours, and

there is practically no labour connected with it beyond stoking the furnace. A tower like this can be used for drying materials containing up to about 25 per cent. weight of moisture. The amount of fuel used is moderate, as a tower with material containing only five per cent. of water will evaporate 5 lb. of water for each pound of coal burnt; whereas, when the material contains up to 25 per cent. of water, the tower will evaporate 8 lb. of water for every pound of coal burnt.



6. SECTION OF A JAW CRUSHER

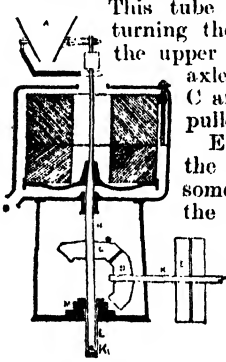
Crushing. In cases where the raw materials are dried in revolving dryers, they have, as a rule, to be crushed before passing into the dryer, but where drying kilns are used, the materials are generally dried just after they come from the quarry. The large blocks are taken directly to a "jaw crusher," before going to the mills for further treatment. Fig. 6 shows a sectional diagram of the most modern form of such an appliance. The framework of the machine is in one piece, cast in steel, and very strongly constructed, as it has to stand a considerable strain. The machine is provided with fly wheels (A) and driving pulleys (B). The material is fed in at C, between the two jaws, of which one (D) is fixed, and the other (E) swings to and fro, being pivoted at F. The axle [K] carries an eccentric rod, which actuates the jaw E by means of levers. The machine is generally placed entirely underground, with a shoot leading down from the floor level to the mouth of the crusher, and a pit under the crusher with an elevator taking away the crushed material as it leaves the machine at M.



5. DRYING TOWER

[Compare plant used for grinding clay in BRICKMAKING, page 1800.]

Grinding. As already mentioned, the dry process is principally used in connection with hard materials, though such soft substances as chalk and gault clay may, with advantage, be treated in a similar way. When working with softer materials of this nature, millstones are often used for grinding, and more especially the bottom runner millstone has been found best adapted in such cases. This form has the advantage over the ordinary, or top runner millstone, in that the material during the grinding rests on the revolving stone, and consequently is moved out from the centre by centrifugal force. This relieves the stones and increases their output. A machine of this type is shown in 7. The material passes to the automatic feed by the hopper A. It passes down the middle, and then between the upper, or stationary, and lower, or revolving stone, and out at B. The lower stone is fixed to the axle H, hung up on a toe at the bottom of an iron tube L. This tube is raised or lowered by turning the nut M, threaded to fit the upper part of the tube L. The axle H is actuated by the cogs C and D, the axle K, and the pulley E.



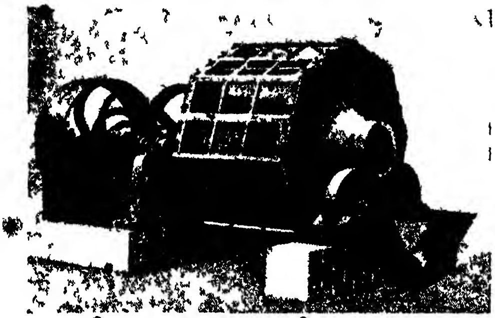
7. SECTIONAL DIAGRAM OF MILLSTONE

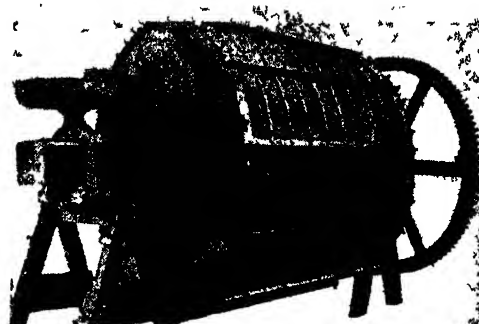
Even with harder materials the under-runner millstone is sometimes used, but the harder the material and the finer it has to be ground, the greater will be the power consumed by this machine, as the stones have to be pressed very tightly together. At the same time the output of each mill will be very much reduced.

Edge-runner mills have also been used a great deal. They are heavy wheels of stone or iron running round on edge in a circular pan or trough, and crushing the material by their weight. [A description of this form of machine, such as is used for grinding clay, will be found under BRICKMAKING.] Runner mills are, however, not very well adapted for really fine grinding, and they are clumsy machines for hard brick or clinker, requiring much power, and suitable only for a few special cases.

Modern Methods. These pulverising machines are arranged to finish the grinding in one operation, but for hard materials we may economise power by dividing the work, using a separate machine for the preliminary, or coarse grinding, and another machine specially adapted for the finishing, or fine grinding.

Ball Mills. For the first operation of coarse grinding, ball mills are almost universally used. This machine consists of a drum revolving on a horizontal axis, and containing a number of heavy, hard steel balls. The periphery, or inner surface of the drum is made up of steps and as the balls fall from step to step, they





8 BALL MILL AND 9 COMMINUTOR, OR IMPROVED FORM OF BALL MILL (KOMINOR)

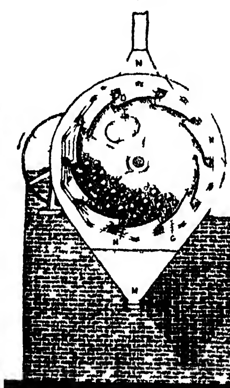
pound up the lumps of limestone or other material Fig 10 shows the mill in section, and 8 gives an outside view

In the ordinary ball mill the steps are formed of a number of plates projecting one over the other These step plates are provided with heavy steel linings, and each is fitted with a number of perforations through which the partly crushed material falls out on to the screens The fine part drops out into the hopper shaped dust casing indicated in the sectional diagram whereas the coarse particles, which are retained on the screens drop back through the holes in the steps into the interior of the mill again as it revolves

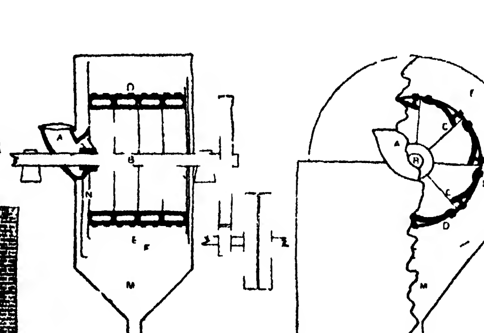
The screens are generally made up of three parts a strong plate with slots or holes, secondly, a coarse steel wire screen and lastly outside these a wire screen of fine mesh

The material is fed in at the centre through a hopper, and is discharged through the perforations in the step plates

Ball mills of this description are used only as preliminary coarse grinders, the finishing or fine grinding, being effected by the tube mill, which is specially adapted for this purpose (see p 2077)



10 BALL MILL IN SECTION



11 TRANSVERSE AND LONGITUDINAL SECTIONS OF A KOMINOR

Improved Ball Mill An improved form of ball mill is the Landhart Comminutor or Kominor [9] This differs considerably from the ordinary ball mills Fig 11 shows a section of the mill and it will be seen that the material enters A at the centre at one side of the mill the discharge taking place through slots at P at the opposite end The material, already partly crushed by steel balls falling over the steps C, passes out at P, and then back again along the whole length of the screens E and F, which are built slightly conical in shape, and the residue, which is not fine enough to pass through the screens into the outer casing M, is lifted up at the inlet end and dropped back again through tubes N into the mill, together with the fresh material which enters at the same time

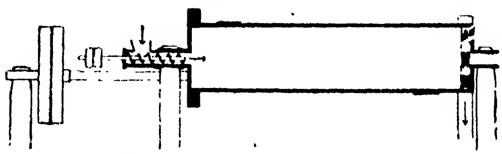
The cylinder CD and screens fixed to the axle B revolve slowly actuated by the pulley L and cogwheels K and H

As compared with the old ball mill this type has several points of advantage First of all, the construction of the mill is much simpler, as the body is a plain drum, the circumference being built of a single solid plate The steps are formed by steel castings bolted on the inside, as at D and easily renewable The grinding action of the mill is improved, as the material is forced to pass the entire length of the drum before it falls on to the sieves whereas in the old ball mill larger particles invariably found their way through the different discharge holes and were constantly falling on the sieve, to be returned again to the mill

The Kominor is a very efficient machine The largest size is made to take a charge of 3 tons of steel balls, and the capacity of the machine will be about 6 tons per hour when used for preliminary grinding of ordinary hard limestone to such a fineness that the particles will pass through a screen of, say, 20 meshes per lineal inch

Method of Mixing. We now come to another and very important step in the manufacture—viz, mixing the raw materials. In some factories, by working with very [illegible] materials of unvarying composition, it is possible to weigh the separate raw materials in the right proportion before grinding, or even before

drying, and simply to mix them together in this state. But, as a rule, they are kept separately during the drying, crushing, and preliminary grinding, because it is much easier and more accurate to weigh them in the proper proportions after these operations. In those cases, especially where the raw materials vary considerably in composition, it goes without saying that large quantities of each material get mixed to a certain extent by passing through the different processes of drying, crushing, and preliminary grinding, and an average composition has already been obtained to some extent before the actual mixing operation begins.



12. SECTION OF A TUBE MILL

Mixing Bins and Extracting Worms. As this careful mixing is of the very greatest importance, mixing bins are commonly used to make the raw materials as far as possible of a uniform average composition.

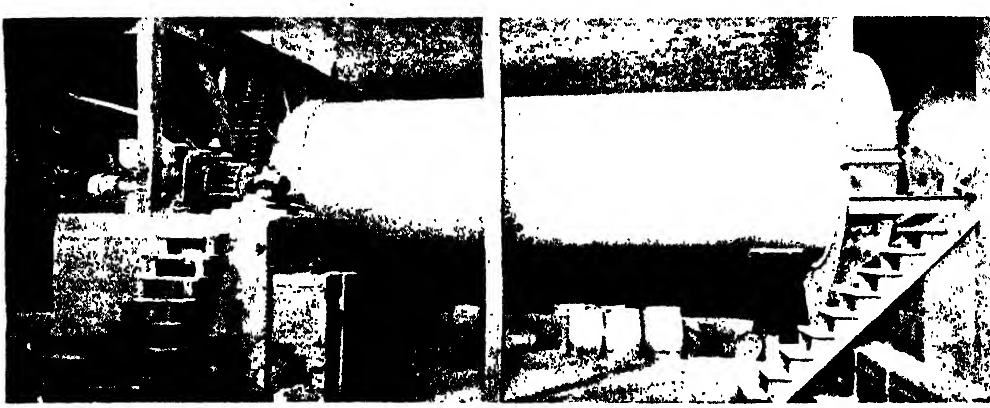
These mixing bins are generally built of brickwork or concrete, and consist of large vertical compartments fitted with "extracting worms" at the bottom, conveying the material to elevators, and thence to "distributing worms" at the top. These worms are attached to a shaft, revolve in a tube, and resemble in construction an Archimedian screw. By their action they push the powdered material along the tube.

Separate mixing bins are used for each of the raw materials, and the weighing and mixing are done after the materials have passed through the bin, and the composition of each has been equalised. The weighing is generally done by coupled automatic weighing machines, which weigh the correct proportion of each material, and discharge them together through a set of regulating worms.

The Tube Mill. The mixed raw materials are then passed through the fine grinding-mill. In modern practice this is almost invariably a tube mill.

This machine [13] was invented by Mr. Davidsen. It consists of a long, cylindrical drum revolving on a horizontal axis. Fig. 12 shows a section through this mill. It will be seen that the feed is at the centre of one end, and is, as a rule, actuated by means of a worm, the speed of which can be regulated at will. The cylinder is half filled with hard flint pebbles or grinding balls of other material, such as iron, porcelain, or stone. The finely ground product is discharged from the mill at the opposite end, at the periphery, through a system of slots or square holes covered with gratings, and the finished material falls into a hopper-shaped dust casing, from which it is taken away by means of a worm or elevator. The material "flows" through the mill by gravitation, and as it is exposed for some time to the rubbing and crushing action of innumerable flints or grinding balls, it will be ground to a very regular degree of fineness.

Capacity of Tube Mill. The tube mill is a machine of very large capacity and output. The biggest machine built will take a charge of about 10 tons of flint pebbles, and will grind 10 tons an hour of ordinary raw material, such as hard limestone, to the usual degree of fineness. The grinding is so complete that 94 to 95 per cent. will pass through a sieve with 180 meshes per lineal inch or 32,400 holes per square inch.



13. DAVIDSEN TUBE MILL

Fig. 13 shows a tube mill of the largest size constructed for grinding raw material in cement works. The finely ground raw materials are technically called *raw meal*.

It is advisable, in order better to secure at this stage absolute uniformity of composition, to introduce mixing bins for the raw meal, similar to those mentioned above. They are provided with extracting worms at the bottom, elevators and discharge worms at the top, through which a large quantity of raw meal, in addition to the quantity necessary for the further manufacture, is constantly circulated.

Various combinations of the wet and dry processes have also been put into operation.

CLAYTON BEADLE and H. P. STEVENS

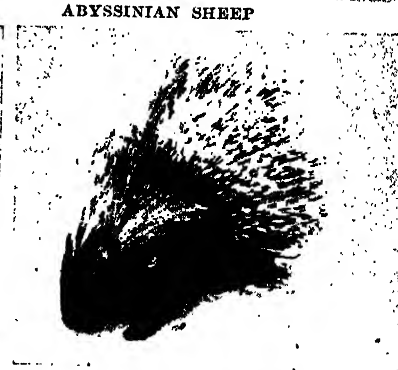
MAMMALS WITH ARMOUR AND ORNAMENT

BLACKBUCK

ABYSSINIAN SHEEP

GREAT ANTEATER

MARKHOR



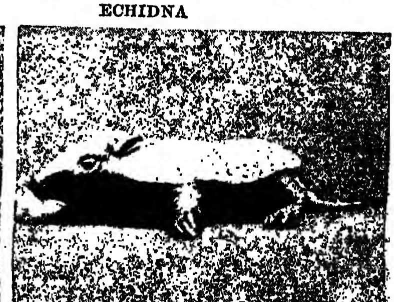
CRESTED PORCUPINE

CANADIAN SKUNK

ECHIDNA

WILD SWINE

MANDRILL



PEBA ARMADILLO

Development of Brains. Horns and Antlers. Skin, Fur, and Scales as Armour. Various Uses of Colours. Other Ornamentation.

WEAPONS & COLOURS OF MAMMALS

The backboned animals which first dominated the land were amphibians, now represented by newts, salamanders, frogs and toads. Later on these were supplanted by a branch of their own stock—reptiles—which adapted themselves to all sorts of conditions, and presented a great variety of groups, most of which are now entirely extinct. The members of this class in their turn yielded to mammals and birds, both of which are improvements upon the remote reptilian ancestors from which they have undoubtedly sprung.

The Blood of Reptiles. The success of both birds and mammals in the struggle for existence is primarily due to the fact that their circulatory and breathing organs have become extremely efficient. The latter purify the blood very thoroughly, and in the former there is no mixing of pure and impure blood, as in amphibians and reptiles, which are both greatly handicapped by this circumstance. They have, in fact, only partly succeeded in adapting the fish type of blood-circulation they have inherited to the conditions that obtain on land. The advantage which birds and mammals have gained in the directions indicated means increased energy, enabling them to cope advantageously with competing lower types.

Mammals, again, have become specially fitted in several ways for both offensive and defensive warfare. All but the spiny ant-eater and duck-billed platypus—now on the way to extinction—have abandoned the primitive device of egg-laying, their young being born "alive." Parental care after birth gives the young animals a good start, and the milk diet provided for them obviates many difficulties as to feeding. Even the primitive mammals just mentioned show great solicitude in the care of their young, and possess milk-glands.

The Value of Brains. An even more important advantage gained by mammals in the course of evolution has been the development of a relatively large brain, which is correlated with marked intelligence, a leading factor in the struggle for existence, and a concrete illustration of the principle that "the race is not always to the swift, nor the battle to the strong." Man himself is, of course, the most remarkable example of this, while, on the other hand, there are certain extinct groups of mammals which have become extinct because their brains did not develop to a sufficient extent, and which have perished, so to speak, from sheer stupidity.

Preservation of the Weaker Orders. Coming now to special methods of defence among mammals, we find that among the weaker orders, such as the Gnawers (*Rodentia*), great fecundity largely compensates for disabilities in other directions, and prevents many species from becoming extinct. The rabbit has become proverbial in this respect. Many, too, of the ill-defended forms have adopted modes of life which have reduced the pressure of competition.

Some of them have taken to burrowing, others have become aquatic, still others are arboreal, and bats have developed organs of flight.

Many mammals are in the possession of more or less efficient weapons, which stand their owners in good stead in the event of attack. Some of these, such as the sharp teeth and claws of the cat-like types, are primarily offensive in character, but serve equally well for the other purpose. And in vegetarian forms we find a great variety of weapons which are primarily of use in what may be termed active defence. A good instance is afforded by the formidable tusks of the elephant and wild boar.

Horns. Actively defensive weapons are also the horns and antlers of many species, of which a great variety are to be found among the Hoofed Mammals. One type is that possessed by the Indian buffalo, the American bison, oxen, sheep, goats, and antelopes. There are here two bony outgrowths from the top of the skull, covered by horny sheaths of varying shape, the sharp points of which are well calculated to meet attacks. Those of the sable antelope of Africa, for example, sometimes enable their possessors to transfix an aggressive lion. In antelopes these weapons are nearly always limited to the males.

Antlers Indicate Age. The antlers of deer, also possessed by the male only, except in the reindeer, as a general rule are of very different character, being bony outgrowths from the skull, which are shed annually, and in many cases become more complex each year, thus serving as an indication of age. Until their full size is attained they are covered with soft, hairy skin, the "velvet," after which a projecting ridge, the "burr," grows out at the base of the antler, and stops the circulation of the blood in the skin-layer, so that it dies and peels away, and the antler itself, deprived of its nourishment, becomes dead bone, to be cast off later. Being insensitive, it makes a particularly serviceable weapon. Antlers, however, are not merely used in active defence, but also in the annual fights which take place between the males for the possession and holding of establishments.

The Unicorn. The curious epidermal horn or horns of a rhinoceros are formidable weapons of quite a different kind, which, like the paired horns of oxen and other animals, are not periodically shed and renewed. The emble-

matic "unicorn" was probably founded upon imperfect knowledge of the Indian rhinoceros by someone possessed of a lively imagination. In one of the dolphin-like Cetacea living in Arctic seas, the narwhal (*Monodon*), a long ivory spear marked with a spiral groove projects from the snout of the male, and was at one time considered to be a "horn." In reality, it is a much elongated incisor tooth, comparable to the tusk of an elephant; sometimes, though very rarely, a pair are present.

Armour. Mammals often possess structures which, being used in passive defence, may be grouped under the heading of "armour." The skin may be very tough and thick, as in the elephant and rhinoceros, or the fur may be so dense as to be a protection. The excessive development of hair on the head and neck of a lion very possibly serves to guard the throat in fights with other males of the same species.

Spines. In several orders a number of hairs are transformed into spines, which help to ward off attacks. Examples are afforded by the spiny ant-eater (*Echidna*) of Australia, the hedgehog (*Erinaceus*), and the porcupine (*Hystrix*). Almost everyone living in the country has probably observed the way in which this *chevaux-de-frise* is displayed to the best advantage by an alarmed hedgehog when it rolls itself into a ball, and remains motionless until the danger is past. A powerful layer of muscle in the skin renders this possible.

Among MAMMALS POOR IN TEETH (*Edentata*) we find both scale and plate armour. The former is affected by the pangolins of Africa and Asia, in which the body is defended by horny, overlapping scales. In the armadillos of South America there are bony plates in the skin which serve a similar purpose Some of these creatures are able to roll up like hedgehogs Other special methods of defence are included under the next heading; and we may here note the great powers of speed possessed by many hoofed animals, their gregarious habits and their powerful hoofs: all contributing to foil or repel attacks Some of them set sentinels while the herd grazes, to give notice of approaching danger. The power of ruminating, or "chewing the cud," which some of them have acquired, has already been mentioned as a protective habit.

The Colours of Mammals. As reference will from time to time be made to animal colouration in connection with various groups, it may be well to give a general classification of colours and markings, to be illustrated for the present by reference to mammals only:

1. Protective Colouration. (*a*) General; (*b*) special. 2. Aggressive Colouration. (*a*) General; (*b*) special. 3. Warning Colouration and Mimicry. 4. Courtship Colouration. 5. Signalling Colouration. 6. Recognition Markings.

Protective colouration is of such a nature that it renders its owner inconspicuous, and therefore more difficult for foes to discover. When it is "general," the result is a harmonising with surroundings of which the animal so protected appears to form a part. This is why the upper side of the body is so often darker than the under, a sort of "reversed shading," which takes away from the appearance of solidity. No better example could be taken than that of the wild rabbit. A less familiar example is that of the rare okapi.

Summer and Winter Dresses of Animals. In countries where there is a marked difference of temperature between summer and winter, some mammals change the colour of their fur. The variable hare, for instance, which ranges east from Ireland and Scotland to Japan, has a dark summer and a white winter coat, the difference being most clearly marked in the northern part of its area of distribution.

Protective colouration is "special" when it brings about a resemblance to some particular inanimate object. A squatting hare, for example, looks very much like a clod of earth. It is said that the two-toed sloth of South America presents a striking resemblance to a lichen-covered bough, brought about by its dull, rough hair, on which a small green alga grows; and in one species there is an oval brown patch between the shoulders, which suggests the broken-off end of the sham bough.

Ermine a Winter Dress. Aggressive colouration is of much the same character as the preceding, but its purpose is different, for it enables flesh-eating forms to escape the observation of their prey. The tawny hide of the lion and the spotted coat of the leopard are cases in point, and so is the white fur of the Polar bear. There may also be, as before, summer and winter coats of different colour. Our native stoat (*Putorius erminea*), for instance, has a reddish-brown back in summer, while in winter in north Scotland it turns white, except that the tip of the tail remains black. This winter dress is the source of the valuable fur called "ermine."

Warning colouration is of such a kind as to make its possessor very conspicuous, and may be taken as an advertisement of unpleasant properties, which only a particularly hungry enemy would care to face. The common badger (*Meles taxus*) belongs to an evil-smelling group, and here the upper side of the body is light-coloured, contrary to the general rule. The American skunk (*Mephitis suffocans*) possesses glands from which it can squirt out an irritating fluid of indescribable odour, and this property is advertised by a white back and a large, bushy white tail, which serves as a "danger flag."

The term "mimicry" is applied to cases where a "mimic," devoid of unpleasant characters, closely resembles a "model" which is defended by warning colouration. Plenty of instances are to be found among insects, as we shall later on have occasion to see.

Moustaches and Courtship. Courtship colouration applies to cases where one sex, usually the male, possesses gay adornments, supposed to facilitate love affairs. We see this in some male baboons, which are decorated with vivid red or blue, both fore and aft. It is not improbable that the moustaches and beards of men were evolved for similar reasons.

Signalling colouration is exemplified by some of the gregarious mammals, and serves to announce the approach of danger. The white tail of the wild rabbit, so conspicuous when it runs, probably has this use. It may also be noted here that buck rabbits warn their fellows by stamping on the ground with their hind feet. The sentinels set by some forms have already been mentioned.

Recognition markings have also been described in some gregarious forms, and are supposed to be a means of keeping individuals of the same herbage, leaving a track that can easily be followed by the sense of smell.

Descent of Man. It is now admitted that the physical structure of man does not separate him more sharply from the highest apes than these, by their anatomical characters, are marked off from ordinary monkeys.

It may be added that the body of a human being is quite a museum of "vestiges" handed down as souvenirs of earlier stages in evolution. Such are the troublesome "appendix" of the

OKAPI OF THE AFRICAN FORESTS—AN EXAMPLE OF PROTECTIVE COLOURATION

species together. Many antelopes, for instance, are marked with alternating light and dark stripes or spots on the upper parts of their bodies, which may perhaps serve the purpose indicated. Another means of keeping communities together is afforded by the possession of characteristic odours. In the peccaries or wild pigs of South America there is a gland on the back which secretes a fluid of unpleasant smell—at least to our way of thinking; and in sheep there are bottle-shaped glands between the hoofs, from which an odorous fluid is squeezed out on the intestine, and a little red fold in the inner corner of the eye, which represents a "third eyelid," found in some lower mammals like the rabbit.

The real differences are to be found in the power of articulate speech, and the faculty of reason associated with an exceedingly large brain. But most probably both speech and reason were both gradually evolved, just as physical characteristics have been. A course in natural history is not the place to discuss in detail so thorny a question, especially as experts are not all agreed.

J. R. AINSWORTH DAVIS

Direct and Indirect Supply. Two-Wire and Three-Wire Systems. Feeders and Boosters. Generators and Converters.

SYSTEMS OF SUPPLY

ELECTRIC energy is supplied to the public on several different systems. As the lamps and motors which are adapted to work on one of these systems are not always suitable to work on another system, it is important that the peculiarities and properties of the different systems should be understood. Also, it is necessary that the meanings of the terms used in describing their arrangements should be made quite clear. The term *system* is itself used in two different ways to mean (1) in general the collection of machinery and distributing mains that supply the current, as, for example, when we say that the Hampstead system supplies 90,000 lamps; (2) in a technical sense to distinguish between one electrical method of supply and another method, as when we speak of a *three-wire* system or of a *high-voltage* system. It is in this technical sense that we use it in this chapter.

Method of Supply. All methods of supply may be divided under two headings, namely, *direct* and *indirect*. In the first there is a direct electrical connection from generator to consumers' lamp terminals; in the second, at one point or more the circuit is broken, and the energy is transmitted across the gap by electric inductive means.

Classification. Classifying the various systems under these two main headings, we have the following table:

DIRECT METHODS	INDIRECT METHODS
Series Distribution	Transformers to step down at sub stations
Parallel Distribution (a) Two-wire (b) Three-wire	Transformers at generating station to step up, and at sub stations to step down
Series-parallel Distribution	Motor-generators in sub-stations
	Converters in sub-stations

Series Distribution. An early way of distributing current to arc lamps was to join them all in series, as indicated diagrammatically in **167**. In such a case the same current goes through all the lamps, and as it must be maintained of invariable strength, the system is also called the *constant-current* system. When this system was in use, one dynamo was designed to give the current to, say, 40 lamps in one series. As each needed about 10 amperes at 50 volts, the arc-lighting dynamo for that circuit was required to generate a 10-ampere current at 2000 volts. In order to extinguish any one lamp, it had to be short circuited, otherwise the rest of the lamps in that series would have gone out also. Had these 40 arc lamps been arranged in parallel the dynamo would have had to work at about 60 volts—allowing a 10-volt drop—and would have had to furnish 400 amperes to the mains, which must therefore have been of very thick copper; whereas, if joined in series, the wire need only be thick enough to carry 10 amperes. Hence the series system lent itself to cases where arc lamps were wanted at long distances apart, with overhead wires. But where there is a regular distributing supply in a town, it is not worth while to put up a separate series system for lighting the streets.

Parallel Distribution. This is shown in diagram in **168**. The lamps are connected individually across the mains by wires which connect across from positive to negative, being thus electrically in *parallel* with one another. The fraction of current which passes through any lamp passes through that one only, and then goes to the return main. Hence the two distributing mains have to be thick enough to carry the sum of all the separate small currents going to the individual lamps. Suppose that in a building wired on this plan there are eight arc lamps taking 10 amperes each, 400 glow lamps of 16-candle power taking 0·25 amperes each, and 50 other glow lamps of 32-candle power taking 0·5 ampere each, then the total current will be $(8 \times 10) + (400 \times 0{\cdot}25) + (50 \times 0{\cdot}5) = 205$ amperes; and the mains supplying that building must be of sufficient thickness to carry that quantity of current.

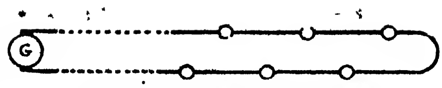
When this simple arrangement is adopted, it is sometimes described as a *two-wire* system, and as the same voltage is always required on every one of the lamps that are connected to these mains, the dynamos must be designed to supply the mains with an unvarying voltage.

Formerly, the two-wire systems in English towns were supplied at 100 volts, and the lamps were made so as to give their proper brightness at that pressure. In recent years the supply is more often given at voltages between 200 and 250 volts, and the lamps have to be made with filaments that are both longer and thinner, and are consequently more fragile. At the double voltage they take, of course, only half as much current to give the same light; but they consume the same number of watts. The advantage is in the saving of the cost of copper in the mains, which may be made, for an equal total energy supplied, of one quarter the weight. Whatever the voltage of the two-wire mains, the method is a *constant voltage* system.

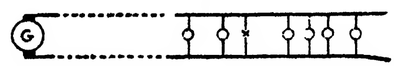
Series Parallel Distribution. Before the makers had found out how to make lamps suitable for 200 volts, a plan of working with 200-volt mains was adopted as shown in **169**, in which two 100-volt lamps were joined in series with one another, and connected across the mains. This plan has the disadvantage that if one lamp goes out the other goes out also. It was proposed to

remedy this by cross-connecting the rows of lamps with a middle wire (shown dotted in 169); but this is not satisfactory unless the middle wire can itself be kept at an exact intermediate voltage. The plan of putting several lamps in series into each parallel branch across the mains is used in certain cases when the distribution is at a high voltage; for example, on some of the electric railways and tramways that are worked at 500 volts it is customary to light the carriages with 100-volt lamps, five of which are connected in series and fed at 500 volts.

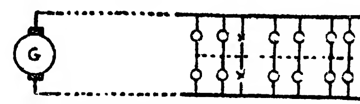
The Voltage Drop. Whenever current is sent through a long conductor, part of the electromotive force is spent on driving the current through the resistance of that conductor. Hence, in supplying current to lamps through a pair of mains, there will be a voltage drop, and the lamps will receive a voltage lower than that of the generator. The amount of the voltage drop is readily calculated in any given case by applying Ohm's Law [page 627], by merely multiplying together the number of ohms of resistance by the number of amperes of current flowing through that resistance. Suppose a current of 80 amperes to be supplied to a house 100 yards from the dynamo, through a pair of mains made of stranded copper of the size known as 37-18's. These mains—that is, the going main and the return main—will together offer 0·0875 ohms resistance, and when the full current is on through them the drop will be 80 × 0·0875 = 7 volts. If, then, the dynamo were to generate its current at 100 volts, the lamps would get only 93. Or, to give the lamps their proper voltage, the dynamo ought to be so compounded [page 1153] that at full load its electromotive force rises to at least 107



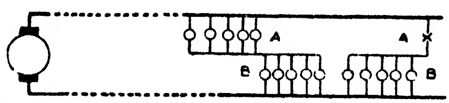
167. SIMPLE SERIES CIRCUIT



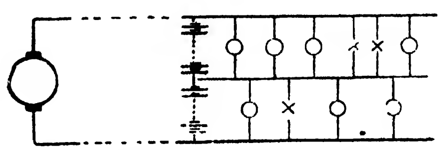
168. SIMPLE PARALLEL CIRCUIT. TWO-WIRE



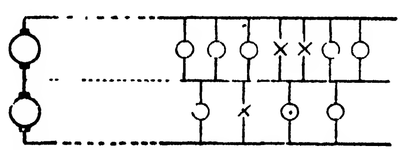
169. TWO-WIRE: TWO LAMPS IN SERIES



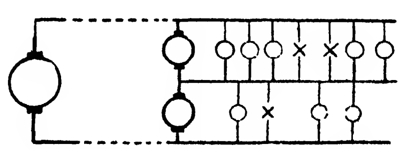
170. TWO-WIRE: BANKS OF LAMPS IN SERIES



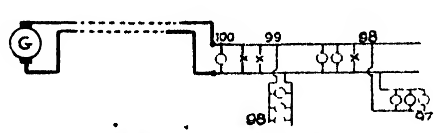
171. THREE-WIRE, WITH BATTERY



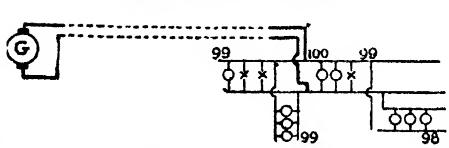
172. THREE-WIRE, WITH TWO DYNAMOS



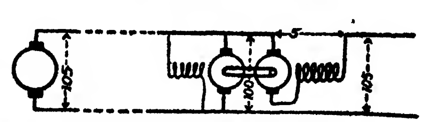
173. THREE-WIRE, WITH BALANCER



174. FEEDER DIAGRAM



175. FEEDER DIAGRAM



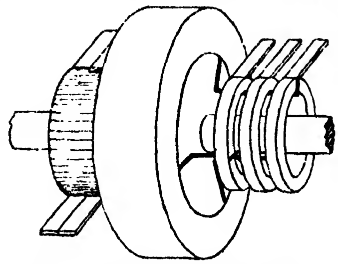
176. DIAGRAM OF BOOSTER

volts. In all distributing and transmission mains voltage drops occur, and must be taken into account in the calculations.

Three-wire System. When lamps at 100 volts were appropriate for use in private houses, the supply companies sought to gain the economic advantage that arises from the use of a double voltage by making the connections shown in 170, where the set of lamps A may represent those in one consumer's house, or in one side of a street, and the set B represent those in another house or in the other side of the street. In this way there is a voltage of 100 only in either A's house or in B's house; yet it is 200 volts between the two outer mains. The disadvantage of such a plan, if this were all, is that the number of lamps which A has alight at one time may not be the same as that which B has alight at the same time; and as the total current going through the two sets is necessarily the same, if A has more lamps going than B has, A's lamps will not get enough current, and will look dull, while B's lamps will get more current than they should, will be over-bright, and will be soon spoiled. Further, in consequence of the inequality in the number of lamps on the two sides, the central connection, or middle wire, will not be at a voltage midway between the voltages of the two outer mains. In this statement lies the solution of the problem. If we can keep this middle wire at a voltage mid-way between the voltages of the outer mains every lamp will get its proper voltage, and take its proper current, irrespective of the number that may be alight on each half of the system.

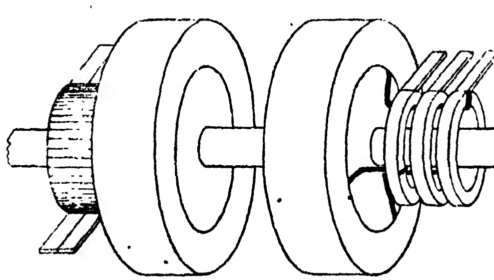
Modes of Balancing. An arrangement to solve this problem is indicated in 171. A battery of accumulators is connected across

the outer mains, and the middle wire of the distribution system is connected to the middle of the battery. In laying out an electric lighting scheme on the three-wire plan, the engineer makes a judicious selection of the streets or districts which are to be connected up to one side or other of the middle wire, choosing them so as to ensure as nearly as possible equal demand for current in both halves. Then the amount of *out-of-balance* current (or difference between the amperes demanded on the A side and on the B side) will flow to or from the battery along the middle wire; and if his choice has been judicious, this in-and-out flow will be relatively small. The battery, in fact, has to supply the balance of current between the two sides of the system, and the middle wire may be thinner than either of the outer mains. The battery may be placed either in the generating station or at some convenient spot nearer the centre of the actual points of distribution.



177. DIAGRAM OF CONVERTER

Figs. **172** and **173** show other arrangements of the three-wire system, for the balance between the two sides may be maintained by other means than by batteries. In **172** we have two similar dynamos, which may both be seen on the same engine, and which are connected electrically in series with one another. In **173** we have an arrangement which is equivalent to a battery at a distant part of the mains, and which consists of two identical shunt motors, the armatures of which are connected in series with one another across the mains. Their field-magnet coils must be suitably cross-connected. This combination is called a *balancer*. Its action is as follows. Normally, both machines run as motors doing no work, generating back electromotive forces [see page 1419] practically equal to those of the mains. If, however, it happens that the consumer's lamps on one side (say, A) of system are more numerous than those on the other side, the voltage between outer and middle will fall a little at one side, and rise a little at the other. Immediately one of the two motors will automatically begin to work as a motor, and give power to the other one, which then works at a higher electromotive force, and begins to generate current and pump it into the side where the demand for current is greater. It thus preserves the balance, and keeps the middle point at a mean voltage.

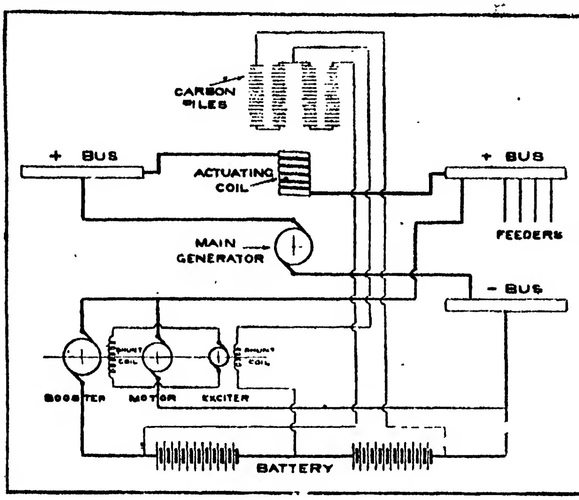


178. DIAGRAM OF MOTOR-GENERATOR

Feeders. In a network of cables used for supplying a town from a central power-house, the cables may be considered as of two kinds—namely (1) *feeding* cables, which go straight from the station to local centres without any intermediate branching; and (2) *distributing* cables, which start where the feeding cables end, and from which are tapped off at many points, wherever necessary to supply another street or a fresh customer, the smaller branch-mains. To minimise the voltage-drop between the power-house and the farthest consumer, the feeding cables are brought to the distribution network at a point selected so as to be as central as possible. This point is quickly made evident by reference to **174** and **175**. In these figures the thick lines represent the feeder cables, which in this case are allowed to produce a drop of five volts by the time the feeding points are reached. In **174** the feeders are connected to the nearest end of the local network, and the voltage-drops are indicated, the greatest drop being at the farthest end, where the 100 volts drop to 97. In **175** the feeders are brought to a central point in the local network, and the voltage-drop at the distant end of the network is thereby reduced to 98 volts.

Boosters. In some cases the drop of volts in the feeder cables, shown above as 5 per cent., becomes a serious item. The drop is not the same for all loads, for it is proportional to the current [see Ohm's Law, page 626], so that in the daytime, or late at night, when very little current is being taken, practically the full voltage of the station (assumed here at 105 volts) is across the distant lamps, which will then burn over-bright; while during the period of full-load in the evening there will be a voltage of 98 or 99 only for these lamps, and they will run dull. Such a wide variation is not desirable, for incandescent lamps are very sensitive to changes in the voltage. Hence, there has arisen a practice of compensating the voltage-drop by means of a piece of apparatus known as a *booster*, which is used either at the station or at the network end of the feeders, to raise or "boost-up" the voltage little by little as the feeder becomes loaded. Fig. **176** is a diagram of a booster, and shows that it consists essentially of a shunt-wound motor driving a series-wound generator. The motor runs at a constant speed, while the current which flows through the armature and field-coils of the generator is the current which is being supplied through the feeder to the network, so that the amount of magnetism in the field-magnets of the generator depends on the current that is being supplied; hence also the voltage added by the generator part is proportional to the load on the feeder. Other methods of exciting the booster are obviously possible.

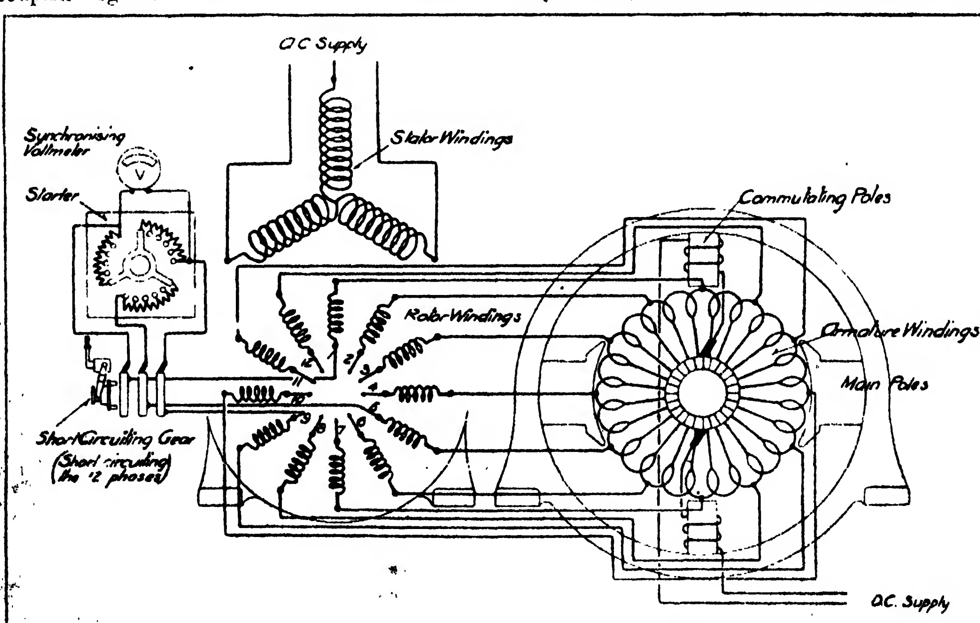
There is, however, another direction in which boosters have proved very effective. This is when they are used in conjunction with a battery either (1) to equalise the load on the generator while there is a violently fluctuating load on the line, or (2) when the load on a small long feeder has to be kept constant, while the load supplied at the far end by the booster and battery is extremely fluctuating. In these cases it is often possible to make savings in running cost equal to 20 per cent. of the total coal bill. There are a number of specially wound boosters designed for this purpose, of which perhaps the most successful and widely used is the "Entz," of which over two hundred have been installed by the Chloride Electric Storage Company [181].



179. ENTZ REGULATOR CONNECTIONS

The booster consists of three machines rigidly coupled together. One is in series with the battery to act as the booster proper, one is a motor to drive the booster, and the third to serve as an exciter for exciting the booster field-magnet coils. This exciter is quite a small machine, being only of 2·5 k.w. rating for a 500 k.w. booster. The essential feature of the booster is the carbon regulator, which is connected in the circuit of the exciter dynamo shunt field-magnet, as illustrated in 179.

This regulator [181] consists of piles of carbon discs whose electrical resistance can be varied by pressure, and the main circuit is made to supply this pressure through a pivoted bar secured to a plunger which is drawn more or less into a solenoid through which the main current flows. The spring to the left of the carbon piles is arranged to balance the pull of the solenoid when the normal current is flowing. Variations from this amount cause uneven pressure on the two sets of carbon piles. When the pressure is normal no current flows through the exciter shunt coil, which is connected in the same way as the galvanometer branch in a Wheatstone Bridge. Whenever, therefore, the current in the main circuit is less than normal, this exciter, and consequently the booster, is excited in the direction necessary to cause the booster to add



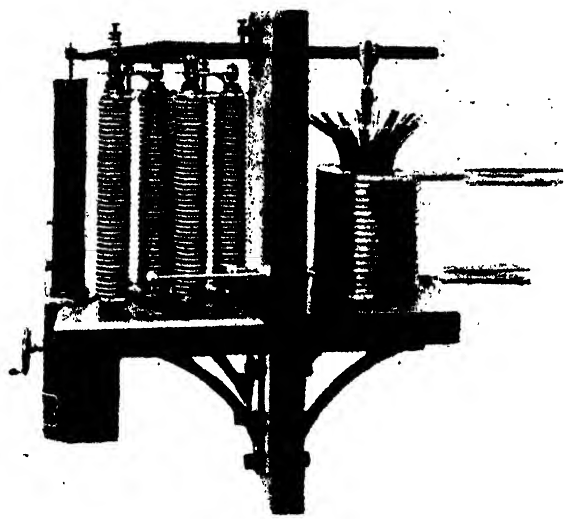
180. DIAGRAM OF MOTOR CONVERTER

to the voltage of the battery circuit; and whenever the main current exceeds the normal amount the polarity of the booster is reversed, and the booster acts in opposition to the battery. In this way, whatever the variations in the feeder circuits, the load on the generators is constant, the battery absorbing the difference between the average load and light loads and supplying the difference between the average and heavy loads.

Indirect Methods of Supply. When the transformation in a sub-station is from alternating to alternating involving only reduction of voltage, stationary transformers [see chapter 12] are all that are needed. There are, however, an increasing number of cases where the supply to the sub-station is alternating, but the demand from the station is for continuous currents for lighting, power, or traction work. We have now the choice between installing motor-generators, rotary converters, or motor-converters, and for particular cases each system has its merits. For low frequencies the motor-generator is generally used. We have here two machines coupled rigidly together—one an alternating current motor usually of the induction type, and the other a continuous-current dynamo capable of supplying the whole of the output. No transformers are needed, as the high-tension alternating current is taken to the stators of the motor. There are, however, the losses in both machines to take into account, and in view of the fact that each machine has to carry the full output these cannot be otherwise than somewhat high.

Rotary Converters. These machines consist essentially of a dynamo having an armature whose windings are connected to the ordinary commutator on one side, and from stated points of the winding to slip-rings on the other, as shown diagrammatically in **177**. If in this case the armature runs at the correct synchronous speed, alternating current supplied by the slip-rings to the armature can be collected from the commutator as continuous current. The losses will be smaller than in the motor-generator set, and there will be one machine in place of two. It will be noted, however, from what was stated on pages 1152 and 1285, that there is a definite relation between the voltages generated in AC and CC armatures, and that, if we want to get 500 volts on the CC side, we must supply three-phase current at about 350 volts. It is therefore necessary to provide stationary transformers to reduce the line voltage to this figure, and the cost of, and losses in, these transformers must be taken into account if a comparison is made between such rotary converters and either motor-generators or motor-converters.

Motor Converters. During the past few years many very large sub-stations have been fitted with motor-converters. These are made by Messrs. Bruce Peebles under the La Cour patents. This system uses two machines, one a motor and the other a generator, rigidly coupled together, but both machines are smaller for a given output than in the motor-generator system, so that the losses are smaller. The switching arrangements are also much simpler.



181. ENTZ REGULATOR

The action of the converter can best be understood from the diagram of connections shown in **180**. The AC end consists of an induction motor, which in this case is supplied with three-phase current. The rotor is of the slip-ring type with a starting resistance, which is cut out of circuit as soon as the converter has started. This rotor is usually wound in twelve-phases, and the machine is arranged to run at half synchronous speed—that is, with 50 per cent. slip. The CC end consists of a generator whose normal full-load speed is equal to half that of the frequency of supply. As this generator is rigidly coupled to the AC end, when that runs at half synchronous speed it runs the generator at its full speed. The ends of the twelve-phase windings on the rotor are connected to the corresponding points on the generator armature. Both rotor and armature synchronise, and maintain a constant speed. The windings of rotor and armature are arranged to coincide, so that half of the energy is transmitted mechanically along the shaft from motor to generator, and half is sent electrically through the windings, the combination acting as a rotary generator. In practice, this machine avoids the principal disadvantages of both motor-generator and rotary converter, and for frequencies over 40 cycles per second it is coming into extended use. In the United States rotary converters appear to be preferred to other means of conversion in indirect supply. SILVANUS P. THOMPSON

Intonation. Major, Minor, and Chromatic Scales. Time Table for Practice. How to Clean the Instrument. Intervals.

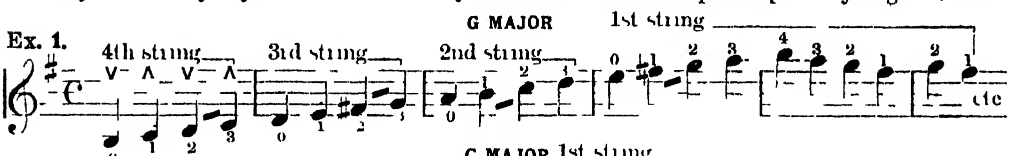
VIOLIN PRACTICE

REFER to the keyboard of a piano if there is any doubt about getting the right notes Of equal importance with the time-sense for the violinist is the necessity to play in tune Accurate intonation in fiddle playing must be cultivated assiduously Gradually the ear will become accustomed to the correct intervals, and identify them without the aid of a piano If it does not, the student had better learn a keyboard instrument, on which the intonation of the notes is furnished mechanically

Slowly and firmly try the scale of G major the open A, the first finger on it the B, the second C close above, and the third D. Lastly, the first string furnishes the open E, the first finger F♮, and the second, close to the first G♮. Go down the scale in the same way Count with each sweep of the bow [Exs 1 and 2].

Music and Numbers. To become an accomplished violinist, the fingers of the player must learn, by diligent practice, to associate tones and numbers automatically In this sense, fiddle music and mathematics are twin brothers When the Greek philosopher, Pythagoras, based

Ex. 1.



Ex. 2.

Begin on the fourth string with a down-bow and sound the open note G If a bar usually begins with a down stroke because of the pressure being stronger, it finishes, as a rule, with an up bow, the last beat being less accentuated than the first. Put down the first finger near the head so as to stop the A above the G Play this with an his series of sound ratios on numbers, he anticipated Corelli, the father of violin players, by twenty centuries The easiest way of committing to memory the numerical fingering of G major, or any other scale, is to vary the order of the notes Thus, if we take a simple melody of moderate compass in that key, we find at once a suitable

Ex. 3.

up bow Place the second finger on the string to sound B Bring the bow down resolutely To get the semitone above for the note C, put down the third finger close to the second. Play with an up-bow. The neighbouring open string supplies the next note, D. Having bowed this, put the first finger on the third, or D, string to get E The second finger will produce F♯, and the third, close to the second, the G♮ above Never raise a finger already down, unless for the production of a lower note on the same string, or a note on another string. The second string gives exercise. For this purpose, the student should now try to play the refrain known as "Katie's Letter," to which we attach the words, so that the notes may be bowed with suitable expression [Ex 3]

In A minor, instead of the semitones occurring between the third and fourth and seventh and eighth notes, as in the major scale, they now come between the second and third and seventh and eighth notes. The effect of this change gives a more plaintive character to the minor than the major modes.

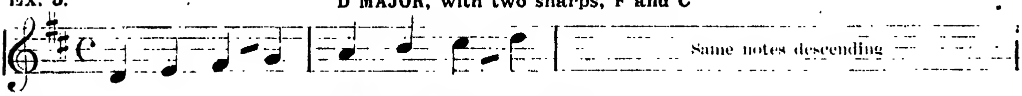
The beginner will now note that, although the semitones are not the same in ascending as in descending a minor scale, the fingering is alike both up and down, the production of the right notes depending on the stopping being "humoured" by the fingers. Below C (the major scale which has no sharps in music) at an interval of a minor third comes the note A. [Exs. 4–8.]

The pupil should now get pen and music paper. To impress on the mind the position of the semitones, it is well to copy out the scales; first, the tonic majors and relative minors, and then the tonic majors and tonic minors, the latter being those minor scales which begin on the same note but have a different signature of accidentals. Having written out the scales in all the sharp and flat major keys, confining the range to the compass of one octave, practise them carefully. To get variety, write the first and third scales in four-four time, the second and fourth in three-four rhythm, and so on.

A MINOR

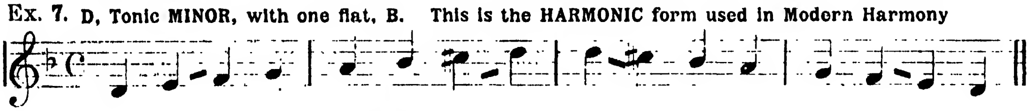
Ex. 4.

Ex. 5. D MAJOR, with two sharps, F and C



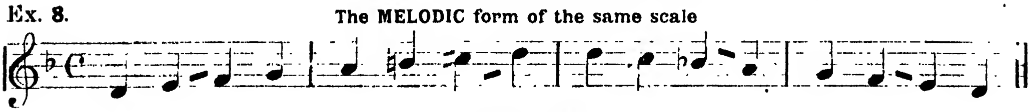
Ex. 6. B, Relative Melodic MINOR of D MAJOR, with same sharps

Ex. 7. D, Tonic MINOR, with one flat, B. This is the HARMONIC form used in Modern Harmony



(Observe altered situation of the half tone in third bar in Harmonic form)

Ex. 8. The MELODIC form of the same scale



(Half tones)

Hymns. In order to impress the correct fingering on the memory, take the top line of some well-known hymn and transpose it into the different keys. Practise it slowly, and try to convey the meaning of the words to the sounds. As correct intonation is of great importance, the student should accustom himself to recognise, before beginning a piece of printed music, the key in which it is written. The "key" to the key is indicated by the last note of an unaccompanied melody, or the bottom bass note of the accompaniment. This is the general rule.

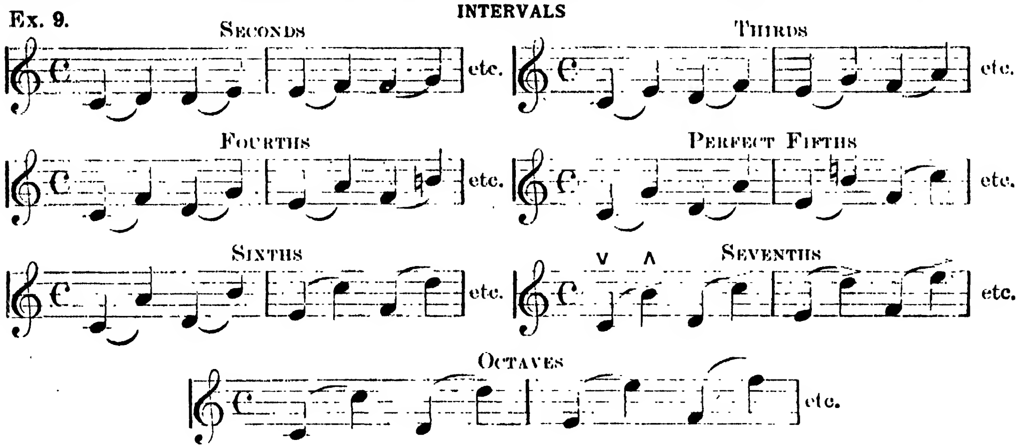
Scales. Many beginners have an unfortunate prejudice against practising scales. Although a badly played scale is decidedly uninteresting to listen to, yet under the bow of a Kreisler or an Ysaye there is nothing more brilliant and beautiful. It is the thoughtless way in which scales are practised that makes them so distasteful. Think, therefore, of a great master playing a scale in an ideal manner. Try to imitate the dignity of his tone in bowing slowly. When, in course of time, the scale can be taken more quickly, the student should always have in imagination, if he wishes to improve his execution, the charm of the rush of brilliant sounds obtained by a clever virtuoso. The beginner's first attempts to play scales may be unhappy, but disappointment is the companion of all true happiness. The latter will come presently and be doubly appreciated if the pupil perseveres. Later on the scales may be extended to two or three octaves. "One thing at a time" should be the maxim of the beginner. If he succeeds in reading and fingering the notes of the different scales within the compass of an octave well in tune, slowly, he will have done admirably. Should the playing of scales become irksome, he has himself to blame for not concentrating his mind on their study.

Difficulties. It is attention to the things which are tiresome to the majority of people which makes for success, and even, in some cases, for genius. In this complex life of ours, the mind, if it be a good one, is strengthened by the difficulties it encounters. In the same way, scale playing strengthens the fingers. There is consequently considerable moral discipline in practising scales not once a fortnight, but regularly every day. The secret of success in singing, it may be whispered, lies in the ability of the vocalist to "scale" the voice beautifully. Of all instruments, the violin approaches most closely, in its methods of intonation, to the human voice. The practice of scales, therefore, is essential for proficiency.

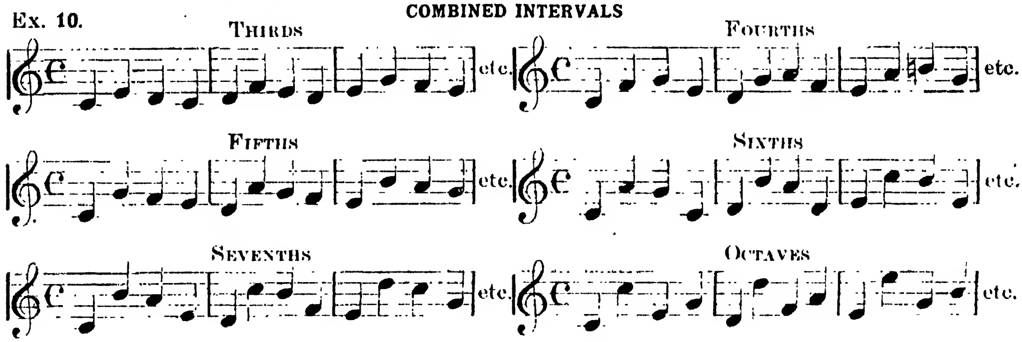
If scale playing has been varied by the slow practice of chants, as suggested, the student will already have begun to make acquaintance with most of the *Intervals* [Ex. 9].

Begin each exercise slowly. Work up the speed gradually. Play each pair of notes with a full bow, down on the beginning of the bar, up on the second beat, and so on. Other methods of bowing will be dealt with later. Having studied the course on Transposition [page 1013], transpose the foregoing exercises into different keys. Next combine the intervals in the way suggested in Ex. 10.

Ex. 9. INTERVALS



Ex. 10. COMBINED INTERVALS



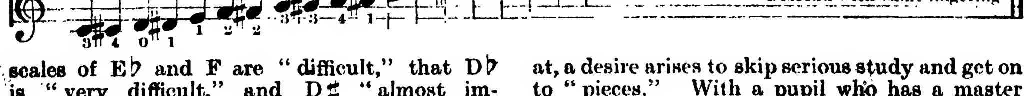
Many sharps or flats may look formidable on paper, but the fingers of the violinist are not confronted, like those of the pianist, with black keys at a higher level than are the ivory notes. Therefore, accidentals should be easy to play on the violin, although Berlioz, in his clever "Instrumentation," gravely writes that the scales of E♭ and F are "difficult," that D♭ is "very difficult," and D♯ "almost impracticable."[1] But Berlioz was a flageolet player rather than a fiddler, and Spohr, one of the greatest of violinists, carries more weight when he says that the violinist has an "equal command of all keys, even those the most remote."

The Chromatic Scale. This question of accidentals leads us to the artificial scale, known as the *Chromatic*, which proceeds entirely by half-tones [Ex. 11].

The student should remember that more than one note in this scale must never be stopped with the little finger, and that the same finger must never be employed thrice in succession. He should avoid also sounding the open E and A strings, whether in ascending or descending. The exact fingering depends a good deal on the character of the music. In moving the second or first finger up or down, be careful to go at once for the precise stopping-place. Lingering midway in the stopping spoils the intonation.

Let us repeat that, if proficiency is to be attained, the student must concentrate his attention on one exercise at a time. As soon as the slightest facility in playing has been arrived at, a desire arises to skip serious study and get on to "pieces." With a pupil who has a master to check him this tendency is bad; but the temptation requires double will-power to conquer when the pupil is working unaided. Instead of frittering away valuable leisure with meaningless tunes, the ambitious student will be

Ex. 11.



better employed acquiring facility in steadily bowing the *Broken Chords* in Ex. 12.

Practise these slowly at first. After getting the intervals in tune, increase the speed. Then proceed to transpose this exercise into all the other major keys.

Arpeggios. When these exercises have been mastered, the student will be ready for arpeggios. These must be practised very carefully, as they are more difficult to keep in tune than scales. First of all take the arpeggio in the key of G major, as written below. It is written in simple triple time; therefore there must be a slight pressure of the bow on *one*. Take the first two notes in one bow, being sure that an equal half of the bow is given to each note. The third beat will be a swift, light up bow which brings it again to the nut. Remember the last note is a dotted minim, and must, therefore, be held on three whole beats.

Before going on to others, it would be advisable to take this same arpeggio in two other bowings. Firstly, take each note with a separate bow. Do not forget to accent the first note of the 2nd and 4th bars, being up bows, as well as the bars beginning with down bows. Secondly, take three notes in one bow, each note getting exactly ⅓ of the bow. See that the bow crosses the strings from the notes B to open D and from 3rd finger D to 2nd finger G very evenly. The student is now ready to go on to the arpeggio in A♭ major.

It is not necessary to repeat where the notes are found, as by this time they should be known by heart. There are no open strings at all in this arpeggio, the A♭ and E♭ on the 2nd and 3rd strings being played with the 4th finger. Try to keep the 4th finger E♭ on the 2nd string while playing the 3rd finger A♭ on the 1st string. It will then be in tune on returning, and will also strengthen these two weak fingers.

The arpeggios of A, B♭, and B majors can all be practised in the same manner.

Practice Table. At this stage the student should make out a practice table. Apportion the time which can be devoted daily to violin study somewhat as suggested above. The plan can be changed discreetly day by day, but 40 minutes at first is long enough for the beginner who takes his work in earnest.

Scale of C major	5 minutes
„ „ A minor	5 „
Intervals	15 „
Broken chords	15 „
	40 minutes

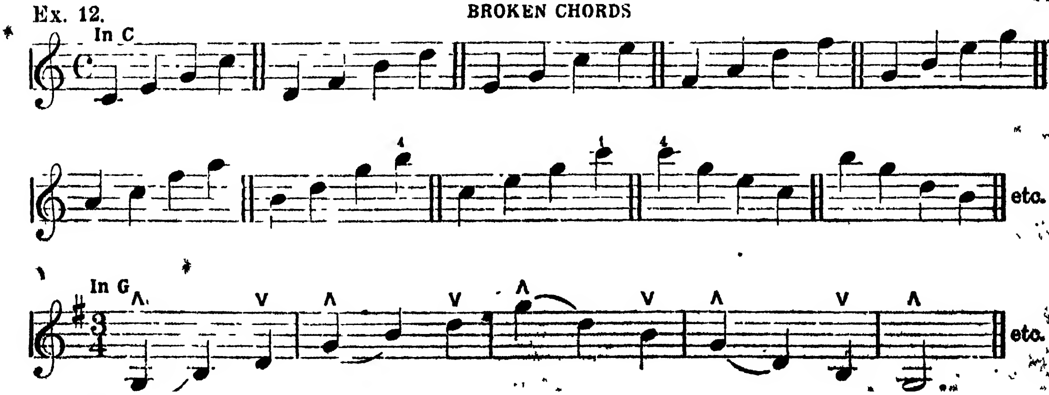
The student will find that it is wise to practise in solitude. If the room cannot be otherwise reserved, rise an hour earlier than usual. In that case, to avoid annoying sleepers, a skeleton, or mute violin, can be bought for about 10s. But these so-called practice violins should be avoided wherever possible. They have a bad influence on the learner, and tend to destroy his conception of tone. A "mute" is better, and can be purchased for a few pence. Placed upon the bridge, it diminishes the sound of the violin. In any case, the beginner desirous of cultivating a good tone should refrain from playing feebly at first. Not only should the bow, both up and down, be made to bite well without roughness throughout its length, but the fingers must stop the strings firmly. This effort may produce corns on the tips of the fingers of the left hand, but in a short time these will give no trouble.

End of Practice. After practice, slacken the hair of the bow. Before putting the violin away, rub off the rosin with a soft handkerchief, and wipe the stick of the bow. Should the fiddle require general cleaning, wipe it with a little light oil, or one of the preparations specially made by the big makers. When the bow gets greasy, wash it with soap and tepid water. Conclude the bath with fresh and cold water. Dry the hair before a fire, then rub with fine powdered rosin.

As soon as the many difficulties which confront him begin to be perceived the first eagerness of the violin student is apt to abate. It is easy then to neglect practice for a while. But such a procedure is fatal to progress, and it is only by resolutely adhering to the plan of study drawn up that the self-instructor will presently become a good player. The beginner must imitate the tortoise rather than the hare if he wishes to triumph.

ALGERNON ROSE

Ex. 12. BROKEN CHORDS



Details of the Automatic and Non-Automatic Looms Employed in Weaving. How Patterns are Woven.

COTTON WEAVING: LOOMS

The general principle of weaving being the same whatever the nature of the yarn woven, it follows that a description of the process applied to cotton includes much that is applicable to weaving at large. Each branch of textile industry has its own specialised form of loom adapted particularly to produce a given class of goods, and the cotton trade is large enough to include almost every kind of fabric and every build of loom, but there is one type which belongs peculiarly to the cotton business.

The Calico Loom. This is the calico or ordinary Lancashire loom [6], which is used in larger numbers than any other. It is a simple piece of mechanism for making simple cloths, with none of the added motions that are required to work a large number of changes upon the two sets of threads. The simplest cloths can be manufactured upon the most complex of machines, but good management demands that looms shall be equipped for their own work and no more. Added motions mean added expense, and manufacturers do not buy those which they do not expect to use regularly.

Weaving-sheds very often contain looms of more than one type, as well as looms of different widths, and machines suitable for heavier or lighter cloths, but the calico loom is the basic type of them all. It is a machine that has undergone only minor modifications since it was first evolved some seventy years ago, and its wonderful efficiency is explained largely by its simplicity. Although it has to be carefully and strongly made, it is probably the cheapest machine that money can buy. A common loom, costing from £7 to £8, is bought at the rate of about 1¾d. per lb. of the metal and wood contained in it, and, in regular operation, its output of cloth may range in value from £100 to £150 per year.

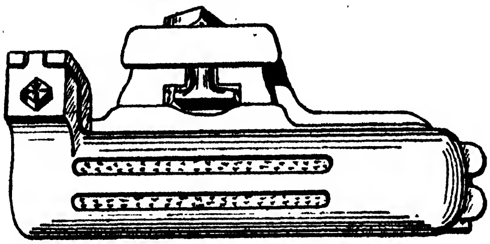
The Power-Loom in Detail. We have seen from the description of the hand-loom that the three fundamental movements in weaving are (1) the forming of the *shed* by parting the warp threads, (2) the throwing of the shuttle to carry the weft between the parted threads of warp, and (3) the beating up of the weft after the warp has been closed. The power-loom is constructed to perform these operations mechanically, with very little aid from the weaver, and at a high rate of speed.

It consists in the first place of a frame of cast-iron combining both strength and lightness. The principal parts of the frame are the sides, carrying the shaft through which power is transmitted. The feet are bolted to the floor, and the sides are bolted together by cross rails. The joints of these rails are accurately machined at the loom works, and the rails are cut exactly to length, for stability is of importance in running at high speeds. An overhead arched rail joins the two sides, and forms a support on which hang the *healds* by means of which the warp threads are controlled. A bracket upon the back of the loom carries the beam upon which the warp has been wound, and above the beam is the back-rest, a roller over which the warp is drawn into the horizontal plane. A chain around the ends of the beam, secured to weighted levers, gives tension to the warp threads and prevents a too free unwinding. Each thread of warp passes through the *mail* or eye of one of the sets of healds, and is secured to the cloth-roller. This roller is driven by the *slay*, or moving part of the loom, and in turning rolls up the cloth as it is woven.

The Function of the Slay. The slay is the part corresponding to the batten of the hand-loom, and it carries the *reed*, a frame of flattened wire bound at top and bottom. The threads of warp pass through the *dents* of the reeds, and are thereby held separate and in place. The slay is mounted at foot upon a rocking shaft, and its sides or *swords* are joined by connecting rods to two cranks, set just inside the loom-framing, and formed by bending the wrought-iron main shaft carrying the pulleys that drive the loom. The slay and reed are given a back and forth movement by the cranks, and the wooden top of the slay carries a shelved *race*-board for the shuttle. The race is slightly inclined toward the reed, and between the reed and the slay the shuttle is shot through the threads opened by the motion of the healds. In its forward movement the slay beats up the weft last woven. The cloth passes over the breast-beam on its path to the cloth-roller, and it is held taut from side to side by the pair of roller *temples* [1] which grasp the selvedge.

The Healds. The main shaft passes through the middle of the loom, and one of its ends carries the fly, or balance-wheel, and the other the fixed and loose pulleys and the brake. A spur-wheel, set between the fly-wheel and the frame, engages with the teeth of a larger wheel, and drives at half its own speed the shaft by which the healds are worked. The healds in general use in cotton weaving are themselves made of hard-twisted cotton yarn, and their eyes are loops of this yarn [7]. The healds are strung along laths, the upper lath serving to lift them, the lower being to hold the heald threads tight. The number of healds in use varies with the pattern to be woven. For weaving plain cloths the number needed is two, which have to be lifted alternately. In the calico loom the *shafts* or healds are lifted by *tappets* or cams set inside the loom framing, and carried upon the secondary shaft.

Overpick and Underpick. The healds are given their motion by eccentrics, and so are the picking *arms*. A shaft is carried upright from the tappet shaft at each side of the loom, and by means of a bracket or cone is given a sharp, intermittent turning movement. The head of this shaft carries a wooden arm, the picking



1. ROLLER TEMPLE

stick, which is made to describe an arc of a circle. The timing of the movement is under the control of change wheels which are fitted in accordance with the number of picks to be made in a quarter of an inch of cloth. The stick carries a leather strap, the *picking strap*, attached at its other end to the picker—a piece of leather sliding upon a horizontal spindle—which delivers the blow that drives the shuttle across the loom. The shuttle when at rest is in a box of planed iron carried on the slay. There are two such boxes, one at each side of the loom, and in connection with each there is a picking motion.

The *overpick* motion just described is that ordinarily fitted upon fast-running light looms, and its name is taken from the position of the stick above the slay. An *underpick* motion, in which the blow is given at a point beneath the slay, is used more in weaving heavier and wider goods than calico.

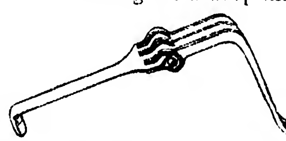
Speed and Safety Devices. In addition to these fundamentals there are almost equally indispensable smaller parts required in the interests of speed or safety. One of these devices is a simple leather strap which extends across the front of the slay. This is the *check strap*, whose function is to absorb the momentum of the shuttle at the instant of entering the box. Short and narrow straps are carried over the ends of the picking-spindles within the shuttle-boxes, and these are buckled to the longer piece of leather, which is drawn slightly from side to side in checking the force of the shuttle. Without provision of some kind the yarn would be thrown off its cop by the force of the collision, and the check strap, invented in 1839 by a Burnley weaver, Robert Pickles, has not been superseded by any of the springs, rubber blocks, or other shock absorbers that have been tried upon the Lancashire loom. The check strap facilitates speed, and the *weft fork* relaxes the need of attention upon the weaver's part.

It is apparent that a loom once set in motion would continue to work although all the thread in the shuttle were done if there were no device to bring it to a standstill upon the exhaustion or breaking of the weft thread. Warp would be let off and taken up, the shuttle would travel, the threads at the selvedge be chafed, and in the end there would be a serious loss of the weaver's time in the endeavour to rectify the mischief. The trouble is avoided by the use of a light hinged fork [2] with prongs which enter the openings in a grate and are pressed back if they find a tight thread of weft in its usual place. In being thus pressed, a catch or hook at the opposite extremity to the prongs is lifted clear and does not come into contact with a projection from the slay. Should the weft be absent, the prongs pass through the grid, the catch is not lifted, and parts are brought into play which throw the driving belt off the fixed, and on to the loose, pulley, so bringing the loom to a standstill and directing the weaver's notice to the mishap.

Precautions against a "Smash." Failure of the weft supply arising from the breakage of the thread is not the worst contingency to be guarded against. More serious injury is caused if the shuttle stops in its flight, and is left between the warp threads in the path of the advancing slay and reed. The result is what weavers call a "smash," which cuts and breaks the threads, and may even break the swords or supports of the slay.

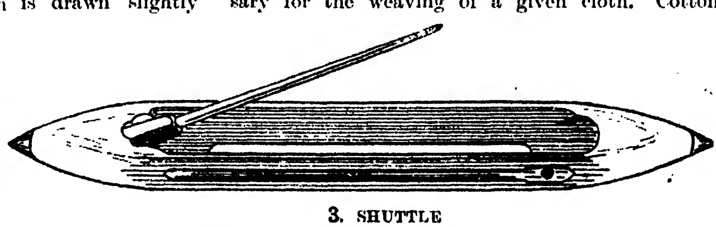
Upon light looms the harm is minimised by use of a *loose reed*, pivoted so that upon meeting an obstruction the lower fastening is loosened and the reed swings back and does not beat against the cloth. The action which releases the reed brings into play a part called the *dagger*, and stops the loom. Loose reeds are unsuited to the heavier cloths, and looms fitted with the *fast reed* are provided with a safeguard actuated by the shuttle. Upon entering the box the shuttle raises a finger upon the shuttle-box. Should the shuttle stop short of its box the finger strikes against a stop and throws the loom out of gear.

The breakage of a warp thread results, of course, in a continuous fault in the cloth, and in weaving goods in which such faults are serious *warp stop motions* are employed. These additions are especially required upon automatic looms, of which one weaver minds a large number, and in connection with them the different forms of warp stop motions are detailed.



2. WEFT-FORK

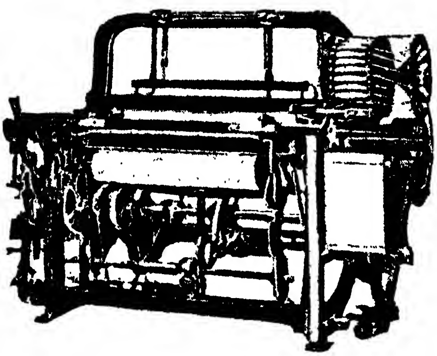
Reshuttling. Men called overlookers or *tacklers* make the adjustments upon the loom necessary for the weaving of a given cloth. Cotton weavers are in nearly all cases women, whose chief business it is to stop and start the loom by its handle, and from time to time change the shuttle by taking out the empty one and replacing it by another filled with weft. The shuttle [3] contains a hinged *tongue*, upon which is placed the weft cop, and when the tongue has been laid back again the weft has to be threaded through the shuttle eye.



3. SHUTTLE

The readiest but least hygienic means of threading is by suction. The weaver puts the shuttle to her mouth and draws the loose end through by a sharp inhalation. "Shuttle-kissing," as the

process is called, has been shown to be a means of spreading contagious diseases, and various devices have been introduced to supersede it. Flexible bulbs and small bellows have been tried as a substitute for the action of the lips, and shuttles which cannot be threaded by suction have been invented



4. THE NORTHROP LOOM

and used to some extent. The insanitary method is in practice the commonest.

The Northrop Loom. Reshuttling occupies time and involves the stopping of the loom, and to avoid this loss attempts have been made to introduce automatic reshuttling devices, none of which has met with conspicuous success. The most largely used of automatic looms aims not at substituting shuttles, but at replenishing the shuttle with weft. The Northrop automatic loom [4], invented by an English mechanic in the United States, is used most largely in America, where there are a quarter of a million at work, as against 15,000 or 20,000 in England and 50,000 in Continental countries. The automatic loom is many times the cost of the ordinary calico loom, and its advantage resides in the ease with which it can be attended. One weaver, with some assistance from a helper, takes charge of between 16 and 24 cotton looms.

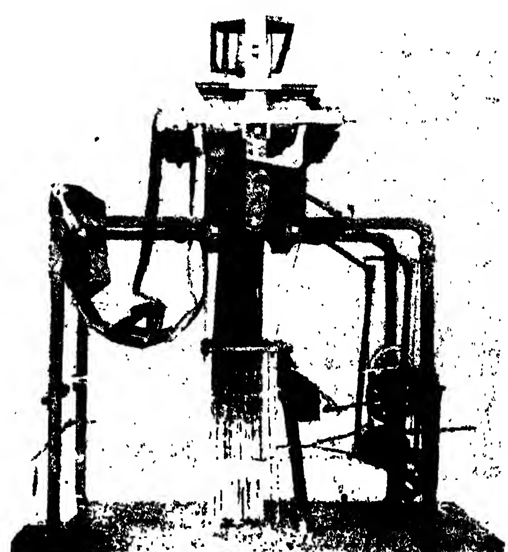
Recharging the Shuttle. The distinctive feature of the Northrop loom is the attachment known as the magazine or battery, used for holding a reserve supply of weft in readiness for the shuttle. This magazine is circular in form, and is made to revolve as required. It carries 25 bobbins or cops of weft, and these are loaded in position before starting. The act of charging takes from two to five minutes, in which time the loom is given enough weft to last a considerable period—usually enough for some hours, although the time varies with the fineness of the yarn and with the number of picks to the inch of cloth.

In loading the magazine the bobbin is placed between supports, a length of yarn is drawn from its nose and is given a turn round the central stud of the battery. The bobbin at the bottom centre of the magazine is set directly over the position occupied by the shuttle-box when the slay is fully forward. The mechanism of the magazine is governed by a special form of weft fork, which feels with its prongs for the thread trailed from the shuttle. If the thread is not encountered, the fork meets a projecting catch fixed upon the slay, and motion is imparted to a *hammer*, or bell-crank lever, which presses the bottom bobbin out of the magazine and into the shuttle, at the same time ejecting the empty bobbin through the bottom of the shuttle. Thus new weft is supplied without stopping the loom.

In order for the transfer to take place safely it is necessary for the shuttle to be in approximately correct position at the moment of change, and, to avoid the breakage that would otherwise follow, a shuttle *position-detector* is added. When the machine is preparing to strike, a metal finger is extended in the shuttle-box, and, should this meet the shuttle, the striker is not raised to the height necessary to complete the transference. If the failure occurs twice in succession the loom is stopped by the same mechanism that brings the machine to a stand when the battery has been emptied.

Warp Stop Motions. The *warp stop* motions used to stop the loom upon the breakage of any end in the warp are made upon more than one system. In the simplest form the healds, which in this case are made of flattened steel wire, act as automatic detectors. The healds are strung on bars through slots wider than the bars themselves, and they are supported individually by the warp threads. On the breakage of a thread the individual heald drops a distance equivalent to the extra length of the slot, and the wire is brought into touch with a serrated vibrator which receives motion from an eccentric upon the tappet-shaft. The vibrator puts a knock-off finger in contact with the starting handle and the loom stops.

In its later form this same mechanical stop-motion is made to depend not upon the fall of the heald, but, in precisely the same way, on the fall of a separate wire detector through the eye of which the warp thread is passed. There are also electrical stop motions in which adjoining pairs of threads are crossed, and a wire that passes between them is held forward until one thread breaks, when



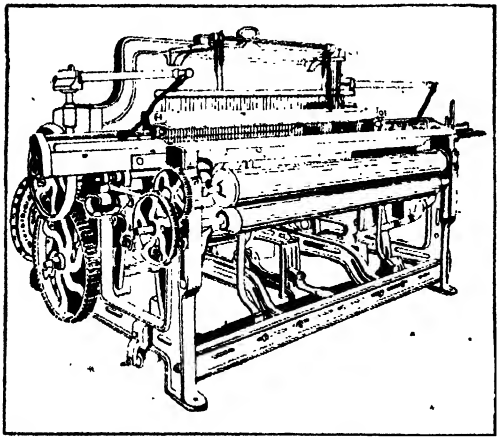
5. MODEL OF THE JACQUARD LOOM

the wire springs back and, by completing an electrical circuit, stops the loom.

Other Control Devices. Among other refinements fitted upon the automatic looms are those for regulating the *letting off* of warp. In one of these the motion is communicated to the flange of the

warp beam from a ratchet worked by the slay sword. The pawl upon the ratchet has its movement governed by the tension of the warp operating upon a spiral spring. As one revolution of a full beam pays out more warp than one turn of a nearly empty beam, some adjustment is needed to secure harmony as the yarn diminishes. In a further improved pattern the beam is made to turn faster as the circumference decreases in size, by the addition of a *beam feeler* resting on the yarn and governing the fulcrum of the letting-off pawl.

In weaving calico the absence of one pick or two picks, caused by the giving out of the thread in the shuttle, is not seriously regarded, but in some other



6. CALICO LOOM

goods the defect must be avoided. In ordinary weaving the careful weaver pulls out of the cloth any short pick left by the exhaustion of the weft and, by turning the loom by hand, ensures that the next thread woven shall be in the right shed.

In automatic weaving the creation of short picks is obviated by introducing *feelers* to feel through an opening in the side of the shuttle how much weft is left, and to operate the magazine apparatus in case there is less than a certain minimum. As the end of yarn from the ejected bobbin still remains attached to the cloth, a separate cutting mechanism has to be employed to sever the thread, and a device for the purpose is attached to the shuttle position detector. This cutter severs the thread at its own point, and also holds taut the severed portion to be cut again neatly at the selvedge of the cloth by the regular thread-cutter in connection with the cloth-temple. Automatic looms are distinguished as *feeler* or *non-feeler* type accordingly as they are with or without this attachment for gauging the length of yarn left in the shuttle.

The Automatic Loom. Pick-*clocks*, or mechanical counters for recording the number of picks made, are attached to automatic looms in some instances, and more rarely to ordinary looms. Automatic looms can now also be fitted with a measuring motion by which the loom is stopped as soon as a given length has been woven. The machine ranks with the most remarkable of mechanical achievements, and it serves for weaving a large range of cloths. It has an obvious limitation in employing only one shuttle, so that the automatic loom is not available for weaving cloth like checks, in which so many threads of weft of one colour have to be followed by a number of a different colour.

Box-Looms. In weaving fabrics with weft of two or more different kinds or colours upon looms of the non-automatic type, it becomes necessary to employ one shuttle for each separate kind of yarn. Such looms are called for brevity *box-looms*, which name signifies that they have more than the two shuttle-boxes that suffice for single-shuttle weaving. Looms of the type are more largely used in weaving worsted goods, and the varieties of boxes in use are more fully treated under that heading.

It suffices for the present to describe briefly one drop-box motion, called the "Eccles," which is often fitted as an addition to the ordinary calico loom. It is an apparatus for bringing the different shuttles successively into play, and it is made to work with as many as six different colours of yarn. The boxes are mounted in an upright frame, and the required box is brought into position by the action of cranks and connecting rods, and while in position it remains securely locked. The motion is imparted through a series of discs, separately mounted, and describing different arcs around a common centre. The discs are revolved by toothed racks, and each rack is provided with fingers movable either towards or away from the disc. These fingers are presented to a chain carrying perforated cards. The perforations in the cards correspond with the order of the changes to be made in the weft, and on meeting a blank a finger is pushed into gear and the disc with which it is connected makes a half revolution. The sum of the movements of the several discs is transmitted to the boxes so that shuttles are presented to the picker in the determined order.

Inside and Outside Treading. We have seen that in the calico looms the healds are raised by tappets or eccentrics, set within the loom framing, an arrangement that is called *inside treading*. The arrangement is suitable in weaving with from two to six shafts of healds, and for work in which frequent change of pattern does not occur. Where a large number of healds must be employed, the tappets are placed outside the framing, usually on the right, and the arrangement is spoken of as *outside treading*. Tappets are used exceptionally to weave from as many as twelve shafts, but it has been found that they are not practicable in making closely picked cloths.

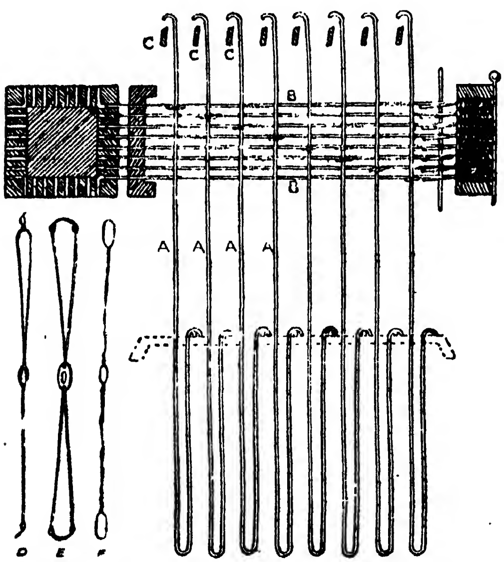
The Dobby. The *dobby* is substituted for the tappets for weaving upon a larger number of shafts, and for the production of small figured effects upon cloth. Dobbies are overhead additions carried upon the top rail of the loom, and while dobbies are made that will lift any number of shafts from eight up to forty, the typical cotton dobby is made for sixteen shafts. With dobby motions for the warp, and box motions for the weft, most kinds of fancy weaving can be executed, but for weaving large designs, which would require the use of a great many shafts of harness, the *jacquard* motion is employed. As the dobby is a modification from the jacquard, a description of the latter is given first, although dobby looms are the more numerous of the two in the cotton trade.

The Jacquard Motion. In the looms described hitherto we have been dealing with shafts of healds, and with the lifting of entire shafts alternately to form the shed of warp. In the full jacquard the healds are lifted, not in shafts, but independently, and the healds are tautened individually by carrying *lingoes*, or weights, and are held separate by passing through perforated boards, known as *comberboards*,

which prevent entanglement. The body of the jacquard machine [5 and 8] is mounted high above the loom upon supports of its own; and although from the great number of small parts it contains the jacquard is formidable to the eye, its operation is not difficult to understand.

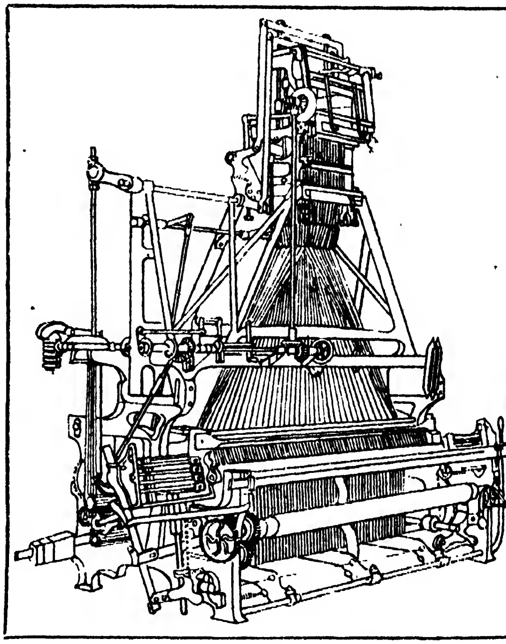
Jacquards are made of widely differing capacities to execute different sizes of design, and their capacity is measured in hundreds, according to the number of *needles* they contain [7]. These needles are strips of tinned wire with one of their ends doubled back, and with an eyelet or with indentations along their length. The needles [B] are set horizontally in a frame, and are pressed by springs at their butt-ends into the perforations of a rectangular block called the *cylinder*. The needles, by means of their looped eyelets or their indentations, govern the position of a set of upright *hooks* [A] from which the *neck cords* of the jacquard harness depend. The hooks are wire, hooked at the point, bent back at the base, and again bent in order that they may rest supported upon a bar. These hooks are set within the bars of a grid or *griffe* [C], and when the griffe is lifted by motion transmitted from the secondary shaft of the loom all the individual hooks and the harness suspended from them are lifted also, unless the point of the hook has been pressed clear of the path of the griffe by its own particular needle. If the needle meets a perforation in the cylinder, the neck cord under its control is lifted by the griffe.

Weaving Patterns. The cylinder is perforated regularly along each of its four faces, and with every pick of the loom it performs a quarter revolution, so presenting its faces in regular rotation. To secure that any particular warp threads



7. HEALDS AND DIAGRAM OF JACQUARD SYSTEM
D. ordinary; E. mailed; F. wire heald

shall not be lifted, it is requisite to cover the corresponding perforations in the cylinder, so that the needle in question shall be pressed back. The face of the cylinder is accordingly protected by an oblong card of millboard which has been previously punched with holes corresponding with the patterns to be woven. The holes allow the needles to penetrate, and the blanks press the needles back. One card is punched for every pick in the *repeat* of the particular pattern, and all these cards are laced together at their edges, and are presented in their order in the form of an endless chain.



8. JACQUARD LOOM

Uses of the Jacquard Weaver. The neck cords form the principals, and they perform all the lifts necessary to produce one copy of the design. If the design has to be repeated a great number of times across the width of the cloth, all that is requisite is to connect the individual healds with their proper neck cords, when the raising of one hook lifts the appropriate warp threads at intervals across the cloth. The jacquard is used to weave border designs simultaneously with centre designs, as, for example, in quilts or tablecloths, and to weave names on towels and sheeting. The action of the *single-lift* jacquard already described is duplicated in the *double-lift* machine, in which two cylinders come into action alternately. Further elaborations are introduced in weaving gauze and double cloths, but these do not affect the general principle of the machine.

It will be apparent that the *tie-up* of a jacquard is a complicated piece of work, and manufacturers, therefore, endeavour by grouping harness to simplify the task, although the grouping imposes some limitations upon the designs that can be woven. Jacquard weaving is somewhat slow, although with the most improved machines the rate of weaving is only about 10 per cent. less than on the dobby.

The dobby lifts not individual healds but shafts, and it is made in different ways by different makers, and in types known as negative and positive, single-lift and double-lift. In dobby weaving there is one card or *lag* for every pick, and into holes in these wood or metal lags *pegs* are inserted which, in acting on levers, bring hooks into contact with the bars of a griffe, and so cause the separate shafts to be lifted in due order. J. A. HUNTER

The Ten Families of Igneous Rocks and their Characteristics. How they Cooled and Crystallised into their Present Formation.

THE OLDEST ROCKS

We have seen that the *igneous* rocks must be the oldest of all, and as it is always well to follow the order of Nature, we shall begin by giving an account of the most important constituents of the earth's crust which belong to this class. Then we shall describe the *sedimentary* rocks, which have been derived from the igneous by the work of natural agents, by weathering, attrition, and deposition. Lastly, we shall glance at the *metamorphic* rocks, which share the characteristics of both these main classes.

The Igneous Rocks. The *igneous* rocks, as their name implies—from the Latin *ignis*, fire—have come into existence through the action of heat. The older geologists divided them into two great groups, according to the circumstances in which they were prepared in the vast laboratory of Nature. Looking back at the history of the earth, as described in an earlier chapter, we see that the whole substance of which the earth's crust is now composed was once in a state of fusion. Thus every rock which we can find on the surface of the earth must once have formed part of an igneous mass; in other words, it was once liquid, like the lava which pours from the vent of an active volcano or the slag of a blast-furnace which is skimmed off the molten iron. But it would be vain to hope to find any part of the earth's surface still in the condition in which it was left when the molten rocks first solidified. The natural agents of change, which we shall study in a later chapter—wind and rain, ice and running water, and all the powers of the air—have been at work for countless ages to modify those primitive conditions [see page 287].

Volcanic and Plutonic Rocks. It is clear, however, that the igneous rocks which we now recognise have had their origin in two ways. They may have been solidified deep down beneath the surface of the earth, and have gradually made their appearance at the level of the ground, where we can now study them, by the double action of those forces which gradually upraise the lower strata in one part of the earth, while they depress the upper portions of the crust in another; or they may have been exposed to view by the slow denudation which is caused by the action of the weathering agents, which also break these rocks down into sedimentary forms, and which are capable—given sufficient time—of removing strata thousands of feet in thickness, so that the giant masses of the Alps are but the trifling remains of the inconceivable mountains which once reared their summits into prehistoric sky. Again, the igneous rocks which we now find on the earth's surface may have been brought to the ground-level in a liquid form by what we call volcanic forces, as is even now happening at Vesuvius, Krakatoa, Mont Pelée, or the other active volcanoes which survive from the remote age when they were far more active and more numerous. Igneous rocks which were produced in the latter fashion are called *volcanic*, whilst those which solidified deep down, and have since been revealed, are called *plutonic*. These names are derived from those of two Greek deities—Vulcan, who was supposed to work inside the burning mountain of Etna at forging the bolts of Jove, and Pluto, who was the ruler of the under-world.

23. PUMICE

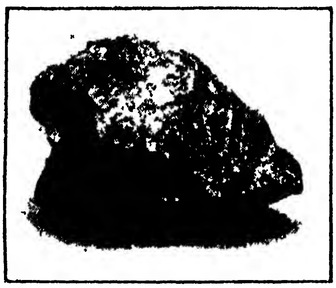
Physical Distinctions. These two divisions correspond to well-marked physical distinctions in the two classes of rocks. The volcanic rocks, which mainly cooled on or near the surface, naturally solidified far more quickly, and are therefore marked by a much finer crystalline structure [see Physics]. Sometimes—as in obsidian, or the so-called volcanic glass—they show no crystalline structure at all. Often they are full of holes, or vesicles, left by the escape of the gases with which they were charged when they first escaped from the vent of the volcano. Pumice-stone [23], in which the holes are more extensive than the substance, is a familiar instance. In general, they closely resemble the slag which the student can examine on the refuse heaps of a blast-furnace. Volcanic products may be *superficial*, poured out in vast sheets on the surface, or *intrusive*, thrust up in *dykes* or *bosses* from the hot interior. The plutonic rocks, however, solidified deep down under the earth, and consequently cooled so slowly that they had time to develop a well-marked and frequently coarse crystalline structure. The immense pressure of the superincumbent rock-masses—often 10 or 12 miles

thick—compacted these rocks as they cooled, and gave them a close texture which left no room for the vesicles, or bubbles, so characteristic of the volcanic rocks. There are other distinctions, but these two are sufficient for the beginner to note. Volcanic rocks show small crystals, or none at all, and are often loose in texture or full of holes. Plutonic rocks are close in texture, and show large crystals. For the purposes of elementary descriptive geology, however, this distinction, though it must be clearly understood, need not be used in classifying the igneous rocks. The same rock is found in both conditions, according to the circumstances in which it was produced.

24. GRANITE, WITH CRYSTAL OF FELSPAR

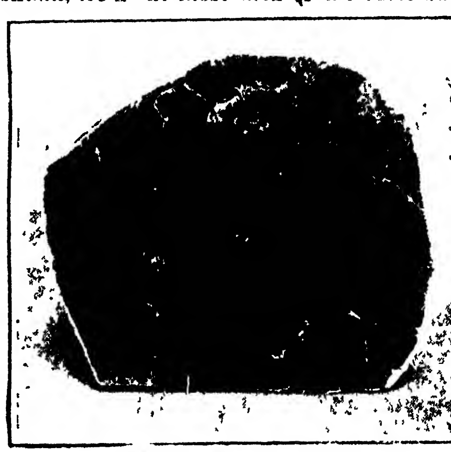
Crystallisation of Rocks. Once upon a time all the igneous rocks existed in the form of a liquid lava. This liquid was closely akin to ordinary molten window-glass, which consists, like it, of a mixture of silicates. Of course, it must not be thought of as transparent, because it contained a great many impurities and colouring matters from which the glass of our manufacture is carefully purified or kept free; but in all essentials it was glass, and sometimes cooled, as in the case of obsidian, into a substance hardly to be distinguished from the coarse glass which is made for bottles. If it was allowed to cool slowly, however, its components arranged themselves into crystals of the fundamental forms corresponding to their chemical composition, and the slower the cooling the more complete was this process o crystallisation. Sometimes it was cut short in the middle. Part of the liquid had crystallised when the remaining *magma*—as it is technically called—was solidified so fast that it had not time to form crystals. Consequently, we find igneous rocks which may be wholly crystalline, like some granites, or partly crystalline, with the crystals set in a formless *matrix*, like porphyry, or not crystalline at all, like obsidian.

Again, the igneous rocks differ widely in their chemical composition, though they are all composed—with insignificant exceptions—of the minerals which have already been described. It is true, by the way, that the exceptions are insignificant from a geological point of view; but, humanly speaking, we must treat them with respect, as they include some of the ores from which our currency and much of our manufactures are derived.



25. GRANITE

Classification of Igneous Rocks. There is as yet no thoroughly satisfactory *classification* of the igneous rocks. There are several more or less efficient systems by which such a classification may be attempted. It is quite unnecessary to trouble the learner with an account of these. We need only say that rocks may be sorted into groups in different ways, according as we consider their chemical composition, their texture, the minerals of which they are built up, their mode of occurrence in the field, their origin, or their distribution in time (geological age) or space (locality). Various attempts have been made to discover a really scientific principle of classification, but as yet they have not been wholly successful. It depends on the object of study whether one or another of the various methods proves to be the most convenient. For our purpose, the learner may be recommended to the classification adopted by Sir Archibald Geikie in his "Text Book of Geology," Book II., Part 2, Sect. vii., where it may be studied at length by those who desire a closer acquaintance with the leading igneous rocks than we can give in these necessarily brief pages. It will be understood that the student must supplement this part of the course by an examination of the various rocks, both in a museum and in the field, and, if possible, by some work in a petrological laboratory, and in a field class. It is sufficient here to give an abstract of Sir A. Geikie's classification, which is based on the chemical and mineralogical composition of the igneous rocks, and arranges them in a progressive order, according to the proportion of silica which they contain, from the most acid to the most basic.



26. MICA (MUSCOVITE)
From Madras

[See the course on CHEMISTRY for explanation of these terms.] There are ten families of the igneous rocks, which Sir Archibald Geikie divides as described in the following pages.

Granite Family. This is by far the most important family of igneous rocks. The granites and their allies compose a very large proportion of the earth's crust, and everybody is familiar with the vast rock-masses and imposing cliffs of granite which play so large a part in the harmonies of the terrestrial landscape and in the operations of human architecture. They are chiefly plutonic in origin.

GRANITE consists typically of the three minerals, quartz, felspar, and mica, which form a thoroughly crystalline aggregate. There are very numerous kinds of granite, which vary (*a*) in the size of the crystals, sometimes so coarse as to be several inches in diameter, sometimes so fine that the naked eye cannot distinguish the crystals of the various minerals from one another; (*b*) in the chemical composition of the felspar and mica [see section on MINERALS]; (*c*) in the presence of other minerals in addition to the quartz and felspar which are essential to the constitution of a granite. For a more detailed account of these varieties the student must refer to Geikie—or to Teall's "British Petrography." He will be well advised also to study all the specimens of granite in any accessible geological museum, from which he will learn how a single rock may present itself in innumerable and exceedingly varied forms, which, nevertheless, can all be referred to a single family. They are the most acid—contain the most silica—of igneous rocks. [24-26]

GRANITE-PORPHYRY is a fine-grained granitoid rock, which consists of a very fine crystalline matrix of quartz and felspar, looking almost homogeneous to the eye, through which are scattered large crystals of felspar.

27. BASALT COLUMNS, GIANT'S CAUSEWAY

QUARTZ-PORPHYRY is a rock consisting of a close-grained matrix (grey, brown, or pink) of quartz and felspar, through which are disposed distinct crystals of quartz. These porphyries—a term reserved for rocks consisting of finely crystalline and apparently homogeneous groundmasses, through which larger crystals are scattered—supply some of the most ornamental of our building stones. They are often confused in popular language with the marbles.

Rhyolite Family. The *rhyolites* are mainly of volcanic origin. Their name signifies this, being derived from the Greek word "to flow." They are distinguished from one another by variations in texture, depending on the conditions in which they cooled from the great lava outbursts of the early world.

RHYOLITE is a typically acid lava, with a high percentage of silica (77 or more). It varies much in structure and texture. Some variations consist of a crystalline aggregate of quartz and felspar which might be mistaken for granite; but the more common form is that of a finely crystalline ground-mass of quartz and felspar, in which occasional larger crystals of these minerals are scattered.

OBSIDIAN, or volcanic glass, is a glassy form of rhyolite which strongly resembles bottle-glass, and, like it, breaks with a conchoidal fracture. It is usually black, brown, or green. About 75 per cent. of its composition is silica, with about 13 per cent. of alumina and traces of other oxides. Its glassy structure is due to its having solidified so rapidly that there was no time for crystals to form.

PUMICE is a rhyolite which has cooled whilst so full of escaping gases that it has developed a spongy, cellular texture, like petrified froth. It is a characteristic volcanic product.

FELSITE is a rhyolite which was originally glassy, but has been devitrified by the process of time until it has developed a characteristic structure, which often causes it to be confused with conglomerate.

PITCHSTONE represents a still further stage of devitrification, and has a resinous or pitch-like lustre, whence its name. It is a volcanic glass, containing tiny crystals of quartz, felspar, hornblende, etc.

Syenite Family. *Syenite*, the rock of Syene, is a holocrystalline mixture of felspar and hornblende, with which mica, augite, magnetite, and quartz are sometimes associated. A typical syenite is a coarse-grained mixture of flesh-coloured orthoclase felspar and black hornblende. There are many varieties of syenite, which are chiefly found as volcanic or intrusive sheets and dykes. Though less abundant than the granites, they play an important part in the formation of rock-masses.

Elaeolite-Syenite Family. These are also intrusive rocks of volcanic origin, which are characterised by the association of the variety of nepheline known as elaeolite with orthoclase felspar. No quartz is to be found in them, since they do not contain enough silica to crystallise out in this form.

Diorite Family. These rocks possess a granitic structure, but contain less silica and seldom any free quartz, whilst they differ from the syenites in containing felspar as plagioclase instead of orthoclase—soda-lime felspar instead of potash felspar. From their typical colour they were formerly known as "greenstones"—a term which has no scientific foundation, though it is still often used for convenience in a hasty classification of rocks in the field.

DIORITE is a holocrystalline mixture of plagio-

clase and hornblende, with traces of other minerals, such as mica and magnetite. It contains about 50 per cent. of silica.

Trachyte Family. The *trachytes* are volcanic rocks whose name signifies that they present a roughness to the finger. Their essential constituent is sanidine, a glassy variety of orthoclase felspar. *Trachyte* is a lava of tertiary and post-tertiary times, which is found in most of the old volcanic regions of Europe. Special varieties are *phonolite*, or *clinkstone*, which gives out a characteristic ringing sound when it is struck with a hammer, and *trachyte glass*, a variety of volcanic glass which is less acid than obsidian.

The Andesite Family. *Andesites*—originally found in the Andes—are more basic than the trachytes, from which they are also distinguished by having plagioclase as their felspar. They usually have a compact ground-mass, in which prisms of felspar are scattered. They contain about 60 per cent. of silica.

Gabbro, Dolerite, and Basalt Family. This is an interesting series of igneous rocks, characterised by their small percentage of silica. "At the one extreme come rocks with a holocrystalline structure like the gabbros, passing into others of a hemi-crystalline character (dolerites), where, amid abundant crystals, crystallites, and microlites, there are still traces of the original glass, and then graduating into types where the texture is still closer, with more abundant ground-mass and often a more basic composition (basalts), until at the other end come true basic volcanic glasses, which externally might be mistaken for the pitchstones and obsidians of the acid rocks. The more coarsely crystalline (holocrystalline) varieties are almost always intrusive in bosses, sills, or dykes. Those of closer texture are often found as superficial lavas as well as in intrusive forms" (Geikie). After the granites, this is probably the most important and numerous group of igneous rocks. We can only find space for a few notes on the leading types.

GABBRO is a coarsely crystalline rock composed of plagioclase (soda-lime felspar), with pyroxene, olivine, and magnetite. The silica is about 50 per cent. The structure is usually similar to that of granite or granitoid.

DOLERITE is usually holocrystalline, and consists of plagioclase, with a ferro-magnesian mineral (augite or olivine) and magnetite. Silica about 50 per cent.

BASALT is a black, very compact, apparently homogeneous rock, with a conchoidal or glassy fracture, in which the constituent minerals can only be observed with the microscope, which reveals a minute crystalline structure. Basalts consist of plagioclase, pyroxene, olivine, and magnetite, and contain from 33 to 50 per cent. of silica. The basalts, of which there are numerous varieties, are typical products of volcanic activity. Some occur as the remains of superficial outbursts, but more commonly they are intrusive, and appear in great dykes and bosses which have been thrust up to the surface of the earth from the heated regions of the inferior crust. Basalt often passes into the condition of volcanic glass when it has cooled very quickly.

28. BASALT DYKE IN AGGLOMERATE

Limburgite Family. These are volcanic rocks of highly basic composition, in which felspar is wholly absent. *Limburgite* is a fine-grained to vitreous rock, composed of augite, olivine, magnetite, and apatite. Silica about 42 per cent. *Augite* consists of augite and magnetite in a glassy matrix.

Peridotite Family. These rocks are the most basic and contain the least silica, averaging about 40 per cent., of all igneous rocks. Their chief constituent is olivine, with augerite, hornblende or mica, and magnetite. They are holocrystalline when fresh, but are usually found in altered states and as intrusive forms of volcanic rocks.

SERPENTINE, as a rock, is a massive form of the mineral serpentine, which is a product of the alteration of peridotites containing olivine. It is a compact of finely granular rock of a characteristic dirty green colour, streaked with brown or red. It is a hydrous magnesian silicate, which is formed by the action of superficial agents from the olivine originally intruded by volcanic action.

W. E. GARRETT FISHER

Hydraulic Rams and Syphons. Types of Water-Wheels. Pelton Wheels. Varieties of Turbines. The Horse-Power of Water.

WATER POWER APPLIANCES

THIS article deals with the applications of hydraulics, the leading principles of which have been already stated. The practical importance of the subject is now greater than ever, and it increases at a rapid rate.

It is not always possible to draw hard-and-fast lines of division between different kinds of water motors. Hydrostatics and hydraulics overlap in regard to their applications. If we attempt to distinguish between weight and pressure, we have already seen that the results of natural head are produced by pressure in the accumulator through the medium of pumps. Kinetic energy, or that due to velocity movement of a liquid, is obtainable from either head or pressure. Head is due to gravity, and the liquid is only the agent through which gravity acts. When we come to the methods of utilising water-power the differences in these acquire a practical interest.

Hydrostatic and Hydraulic Machines. The distinction between the hydrostatic and hydraulic machines may be put tersely thus: in the former the liquid has no energy of motion, but only that of pressure; in the second pressure is employed to produce motion, and the energy of the motion is that which is utilised for doing *work*. In strictness, therefore, the various so-called hydraulic engines belong to the same class as the press cylinder and rams, and not to the turbines and allied machines. They are so designed that with little essential modification they can be used for liquids and gases alike, a point we shall note in rotary blowers and centrifugal pumps. One of the best-known engines, the "Brotherhood" three-cylinder type, can be, and is, actuated by steam pressure, or water, or compressed air, as in torpedoes.

The capstans which one sees on quay and dock walls are often operated hydraulically by means of engines with oscillating cylinders, the pistons of which all drive on to the crank, which, being continuous with the shaft that operates the mechanism to which the engine is connected, drives it. In the capstan this shaft is the one to which the capstan head is attached. In some cases the "Brotherhood" three-cylinder type of engine is used, in others, four cylinders. The pressure water enters and leaves through passages in the cylinder trunnions. These passages are opened and closed by the oscillation of the cylinders.

The Hydraulic Ram. This machine, which utilises the kinetic energy of moving water to raise a portion of that water to a very much higher level than the source of supply, is not a paradox. It does not contradict the law that water can only find its own level. The problem is not hydrostatic, but dynamic. Given a constant water supply, therefore, it would come near fulfilling the ideal of perpetual motion.

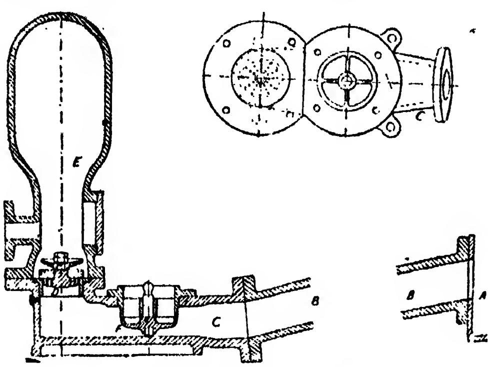
In this machine [129] water flows from a source of supply, as a pond or tank, A, under a head, coming through a sloping pipe, B, the *drive pipe*, into the ram. This consists of a casing, C, having two valves, and an air vessel. The valves are the check valve, or delivery valve D, opening into the air vessel E, and the dash valve, or door F, opening downwards into the casing, and dropping by its own weight. It comes between the source of supply and the check valve and air vessel, to which the delivery pipe is connected at G, and which is connected to the cistern or other vessel which has to be supplied with water. The action is as follows.

How the Ram Works. When the valve (not indicated) which closes the mouth of the drive pipe at the feed tank end A is opened, the water flows down the pipe B into the ram C, and begins to escape by the dash valve F. But almost immediately the impact of the water on the under side of this valve lifts, and closes it, preventing any further escape for the moment in that way. The momentum of the water, thus arrested for a time, raises the pressure in the body of the ram, lifting the check valve D communicating with the air vessel E, and some of it passes into this vessel. Then there follows a recoil of the water into the drive pipe, which allows the dash valve F to drop, allowing some water to flow past it, and the cycle of operations begins again, and is repeated from 40 to 200 times a minute. At each movement a little more water is driven into the air chamber E, compressing the air therein, and being in turn ejected through the only outlet possible, that into the delivery pipe G leading to the storage.

Advantages of the Hydraulic Ram. Thousands of these valuable little pieces of mechanism have been fitted in country houses, farms, and institutions where there is no public service water available. They are made in more than a hundred modified designs, only one of which is shown, to suit all kinds of conditions, until nearly all things are possible to the possessor of a suitable ram. It will work 24 hours a day with practically no attention. It can be made to work with large or small quantities of water, from 1 to 2,000 gallons a minute, and to suit falls of from 18 in. to 100 ft. Hydraulic rams are designed to raise from 300 to 500,000 gallons a day. Some of them will force water to 1,000 ft. in height. By comparison with other methods of water raising they show to much advantage. Windmills, water-wheels, pumps,

engines, electric motors, all suffer from various disadvantages due to their greater cost and complication, besides which they all require more regular attention than rams do.

The Syphon. The syphon is not a mere toy, or a device utilised on a small scale by a gardener or plumber for emptying a tank or cistern. It is the principle employed on an immense scale in bringing water-supplies to cities. Only in these cases the syphons are huge pipes inverted, and having numerous valves at certain points of junction for the prevention of the flow, or return of the water in cases of accident to the pipes. The Romans built magnificent aqueducts for the supply of water to their cities, and in this respect put to shame the insanitary nations of the long Middle Ages. But they do not seem to have understood the syphon, for they always carried their aqueducts horizontally on immense arches of masonry over the deep valleys. The modern engineer simply lays down pipes of cast iron or steel following the contour of the valleys, knowing that water will ascend in the endeavour to find the level of its head. The system is used in the American and Russian oilfields, as well as in numerous aqueducts, as the Croton, where a syphon passes under the Harlem River in the United States, and in the Manchester-Thirlmere, the Birmingham-Welsh, the Liverpool-Vyrnwy, and other British water-supplies.

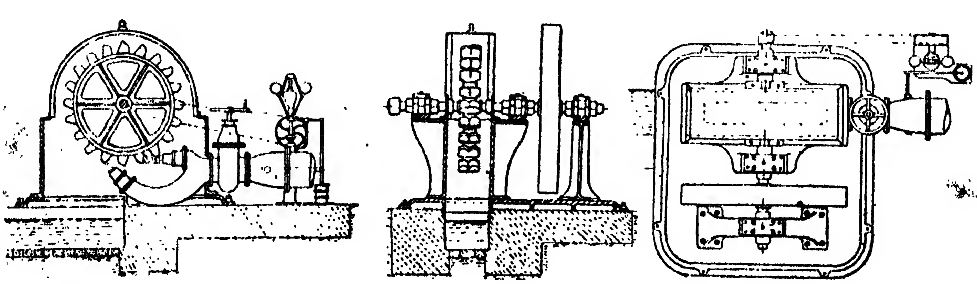


129. HYDRAULIC RAM

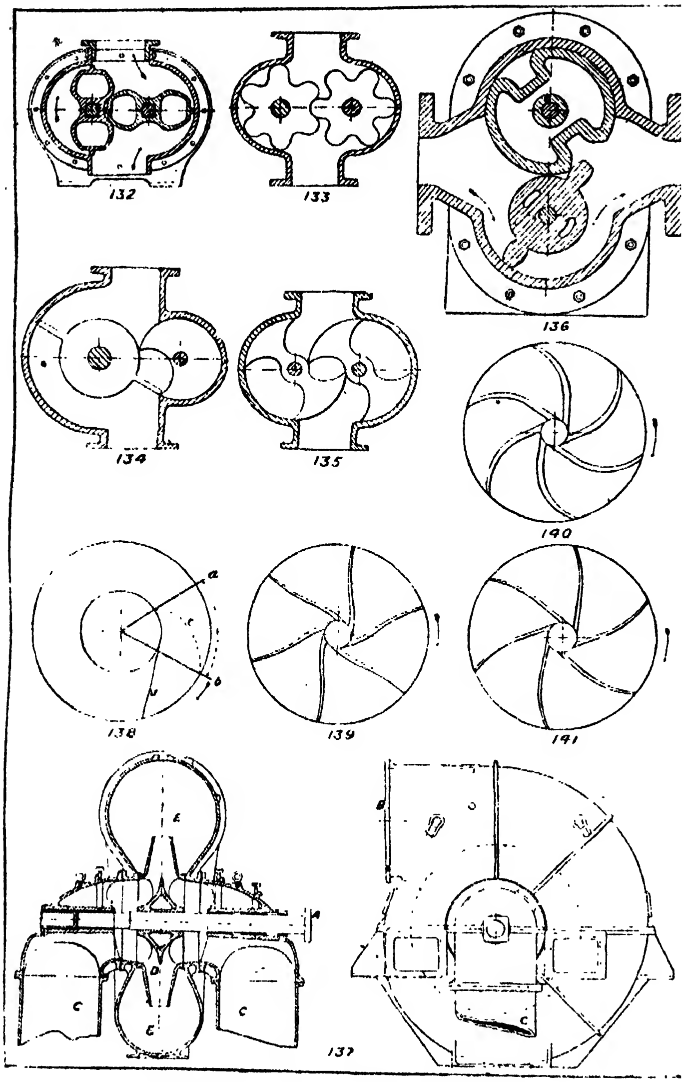
Chamber Gears. We must not pass without notice a group of mechanisms, which are more familiar in the form of blowers than of water-pumps, and to which the term *chamber gear mechanisms* has been given. Roots' blower [132] is the most familiar form, but everyone does not know that this has also been employed as a rotary pump. Two two-lobed wheels revolve in contact with each other and within their casing. The lobed wheels or pistons, being rotated in unison by an external source of power, propel liquids as well as gases. There are several types of these rotary pumps, of especial value for viscous liquids, and they are interesting studies in applied mechanics. Fig. 133 is a rotary pump which is simply a pair of toothed wheels of the gear type rotating and interlocking. Substantially, the difference between 132 and 133 is that the wheels or *impellers* in the first have two teeth each, those in the second have six. The contact is constant between the wheels and their casings, so that fluid cannot pass through in a direct course, but must occupy the spaces swept through by the rotating wings or teeth. Fig. 133 is familiar in machine shops in the form of an oil or suds pump for lubricating tools. Fig. 134 is a form used as a blower. It will be recognised as identical in principle with Baker's well-known blower, the latter having two small discs instead of one; and this has been used as a pump. Fig. 135 is a modified Roots' blower, also used as a pump for other liquids besides water. Fig. 136 is another type in which the revolving bodies are unlike, two teeth on one filling spaces in the other, and during the intervals the circular bodies are in contact. It is termed the *drum pump*. The movements of the two pistons create a vacuum, into which the water flows, and becomes forced out by the front face of the smaller piston.

130. SECTION OF DRUM PUMP

The Drum Pump. This pump is suitable for removing semi-liquids, such as slurry, or wastes from breweries, paper mills, soap manufactories, etc. It consists of a revolving piston sweeping out the cylinder at every revolution, the revolving piston dipping into a revolving valve or cylindrical drum, the openings in which are arranged so that the piston passes through without slip, back pressure, or undue friction. When the revolving piston moves round from the revolving valve a vacuum is formed, into which the water flows and is forced in the front face of the piston. The action of the pump is shown in 130.



131. THE PELTON WHEEL



132–141. TYPES OF ROTARY PUMPS

Centrifugal Pump Blades. The blades or vanes are generally curved, because that is the form which is the most efficient in the propulsion of the liquid from the centre to the circumference of the casing. We shall meet with similar curves directly in turbine practice. High speed is essential in any case to the efficiency of these pumps.

The curves or the vanes are referable to radial lines, thus: if a rigid rod [**138**] revolves about a centre and carries a loose ring upon it, which we may suppose to be a particle of water, the ring will move to the end of the rod under the action of centrifugal force. But in doing so the path which it describes will not be a radial one, but a component of radial and circular motion. In passing from *a* to *b*, the path taken by the globule will be that indicated by the dotted line *c*. If the rod be inclined away from the direction of rotation, as at *d*, that will favour the outward movement of the globule, and the steeper the angle of inclination the more rapidly will the ball be forced out to the circumference. Though pumps are made with straight inclined blades, it is better to curve them, and the shape of the curve may be approximated by moving a pencil in a radial direction across the face of a revolving disc.

It will be found that curves will be described resembling in form the vanes used in pumps, and the more rapid the rate of rotation the larger will be the amount of curvature or spiral developed. These, therefore, indicate the approximate forms of the vanes of pumps of this class, examples of which are given in **139** to **141**.

The Centrifugal Pump. This pump [**137**] will be recognised also in the form of the fan, so that here, too, a mechanism is used either for liquids or gases. The blades or vanes are rotated within a casing, from any convenient source of power, coupled to the shaft A, and will pump water and other liquids, clean or dirty, as there are no valves to become choked up. The same mechanism is used for dredging sand, gravel, and mud, just as the centrifugal fan is employed in extracting sawdust and shavings from woodworking machinery.

Fig. **137** represents a 52 in. pump by Tangyes, Ltd., the measurement being that of the discharge opening B. It is a double suction pump—that is, the liquid enters by two tubes, C, C, diverging from a single pipe and opening into the pump at the sides, where the liquid develops kinetic energy by the revolution of the vanes D, and being discharged at the coned openings and passing round the volute-shaped casing E, escapes at B.

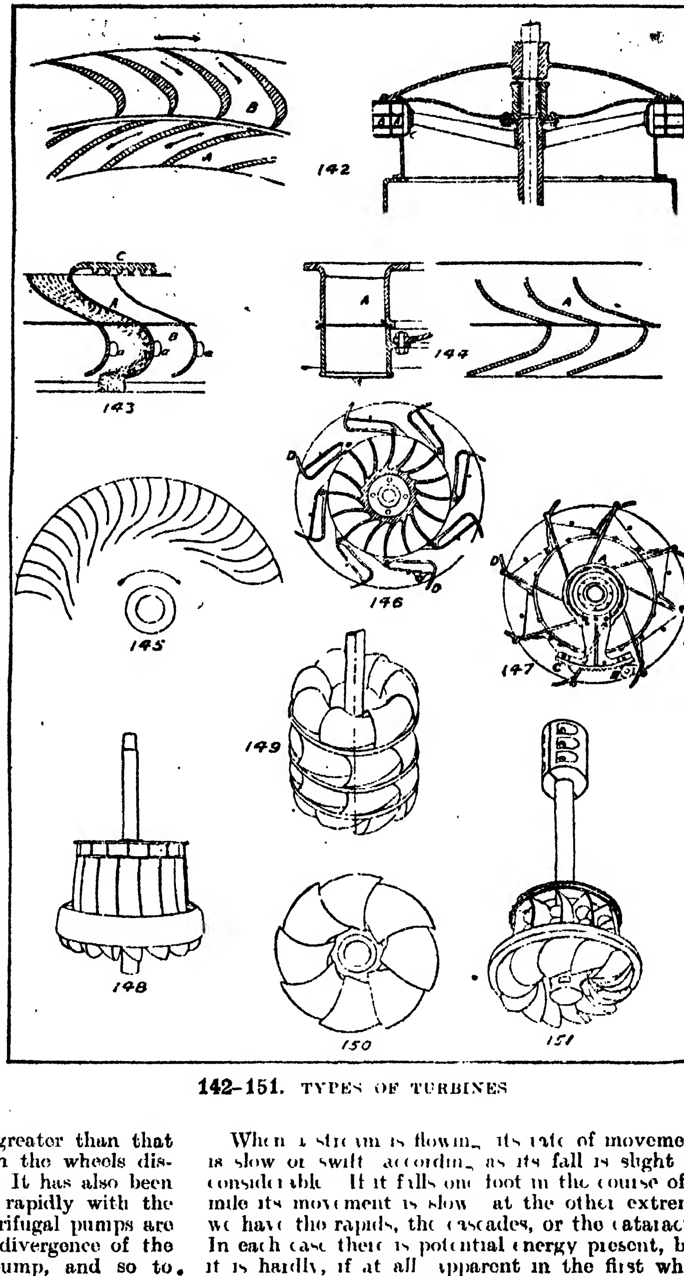
Curvature of Blades. It must not be imagined, however, that the determination of the most suitable curvature, or the question of straight inclined blades versus curves, is so simple as the foregoing elementary example would seem to imply. The whole subject bristles with difficulties, and the form of the volute, and of a whirlpool chamber in some cases, has much influence on results. Only by much experimenting and experience have the pump manufacturers been able to produce the most efficient pumps for different speeds and heights of lift.

The real behaviour of a pump that is modified in design only slightly from previous examples has to be ascertained by experiment. Curious anomalies have come out sometimes. But the net result is that a given pump has some particular speed and height of lift which is its maximum possible. And it is found that there are limits below, as well as above, at which a pump will

not work efficiently, though the latter case only is often accepted.

Mechanical Efficiency. The centrifugal pump is substantially the inward flow turbine reversed. That seems a very simple fact. Yet the mechanical efficiency of the pump is much less than that of the turbine. While the latter converts about 80 per cent. of the potential energy of the water into useful work, the centrifugal pump rarely gives out more than 55 or 60 per cent. of the work put into the shaft, and frequently not so much as that. The explanation offered is that in the turbine potential energy is converted into kinetic, but in the pump the kinetic energy of the water leaving the vanes is translated into the potential form—that is, in the form of pressure or shock. To reduce this is the object of curving the vanes; also of discharging the water into guide passages of gradually increasing area, as the volute [137], until the velocity is sufficiently reduced. And, finally, to allow water leaving the wheel to form a free spiral vortex in the pump-casing.

Aim in Construction. In the construction of these pumps, as of turbine buckets, the object is to proportion the curves so that the water shall pass through with the least friction, and leave the buckets with as little velocity of movement as possible, because velocity means so much energy wasted. A secondary advantage of curved vanes is that as they permit of more slip between their faces and the water, they are more favourable to efficiency under a larger range in speed than radial vanes are. Experiments by the Hon. R. C. Parsons showed that invariably the efficiency of wheels with curved vanes was greater than that of those with radial vanes when the wheels discharged into a vortex chamber. It has also been proved that efficiency increases rapidly with the quantity of the discharge. Centrifugal pumps are coned in order to decrease the divergence of the streams passing through the pump, and so to reduce the residual energy.



142–151. TYPES OF TURBINES

Water-Wheels. These come on the border line of mechanisms that act by gravity, and by kinetic energy. They act mostly by gravity—the turbines do so by energy of velocity. But in some forms of the water-wheel gravity force develops into that of momentum, and in some forms of low-pressure turbine gravity is the principal form of force. We shall, therefore, consider in brief the characteristics of the principal types. But first it will be desirable to show by what methods the potential energy of flowing waters is coerced and utilised.

When a stream is flowing, its rate of movement is slow or swift according as its fall is slight or considerable. If it falls one foot in the course of a mile its movement is slow; at the other extreme we have the rapids, the cascades, or the cataracts. In each case there is potential energy present, but it is hardly, if at all, apparent in the first while obvious in the second. One can hardly realise latent energy in the Thames, but it is striking and grand in Niagara.

Value of Dams. But if we should dam the Thames, the potential energy of the stream would become apparent. When old London Bridge was in existence, the narrow arches dammed the water back so much that several feet of head was utilised for driving water wheels. The effect of damming is simply to raise the level of the water at that locality, and so concentrate at one place the energy due to gravity which had been previously dissipated over a long upper reach of the stream. If, for

instance, a river has a fall of 10 ft. in a mile and a barrier is stretched across its course 10 ft. high, the water will drop 10 ft. sheer, and will give out the energy due to 10 ft. of head. This was the device of the old millwrights, who drove water-wheels by gravity acting through the head of water.

Actually, 10 ft. is a rather low head, and requires a large volume of water to make it very efficient. At the other extreme, therefore, there is the cascade, many scores or hundreds of feet in height, but having its potential force broken up and dissipated on a series of rocky steps. But if it be enclosed in a chute or a pipe so that the frictional losses due to the broken waters are minimised, it becomes capable of exercising powers that are often measureable in that of many hundreds of horses.

The problem now becomes how best to utilise the *low* and *high heads*, as they are termed. An enormous amount of water motor engineering centres around them, but nearly all are capable of classification under the two headings—water-wheels and turbines.

Water-wheels are classed as *overshot* when the water comes over and nearly at the top of the wheel; *breast* when it comes between the top and centre, sub-divided also into *high* and *low breast* wheels; *undershot* when the water comes at the bottom of the wheel.

Overshot Wheels. In these wheels the water is brought along a shoot—the *head race* above the wheel—and is discharged into the curved buckets immediately beneath. It is, therefore, essentially a gravity wheel, though, as the water must possess some velocity at the moment of discharge, that must be credited with a small portion of the results. The buckets are curved to retain as much of the water as possible before it is discharged into the *tail race* with the revolution of the wheel.

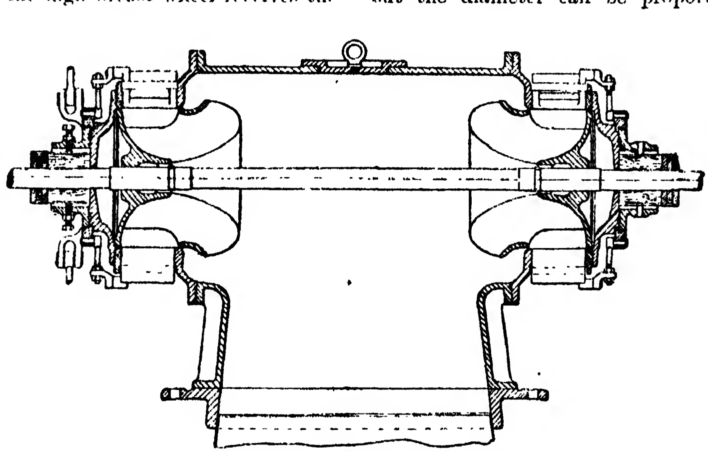
Breast Wheels. In these, water is introduced somewhere between the top and the middle of the wheel, and therefore it acts chiefly by gravity. An advantage of this type is that the movement of escaping water is assisted by the rotation of the wheel. The buckets are either curved or faceted to approximate to curved forms. Though the high breast wheel receives the water nearly at the top, it differs from the overshot in the direction in which the water is brought to it, being *against* the buckets instead of *over* them.

The Undershot Wheel. In this wheel we have what is really a connecting link between the water-wheel and turbine, since the water does not act by simple gravity, but by its momentum, or kinetic energy, due to the head. There are two groups of undershot wheels—that with straight vanes and that with curved buckets, an important distinction which will form a text for the discussion of the forms of buckets in general.

When water impinges against flat vanes, eddies are produced which waste some of the power. By substituting curved vanes, with the concavity facing the water, the water runs up their faces, until arrested by the action of gravity, when it falls again. But it exercises pressure, and does work during both movements. This simple device of curving the buckets is applicable to all kinds of water-wheels and turbines, and has been the subject of many formulæ. The original idea appears to have been due to Fairbairn, who substituted curved iron buckets for straight wooden ones. Another improvement due to him, applicable only to the overshot and breast water-wheels, was the ventilating bucket—that is, a narrow space was left between the bucket and the rim of the wheel, from which the bucket starts. Any air imprisoned with the water in its descent escapes through this space into the bucket above, instead of occupying space that should only be filled with water, and so dashing the water out.

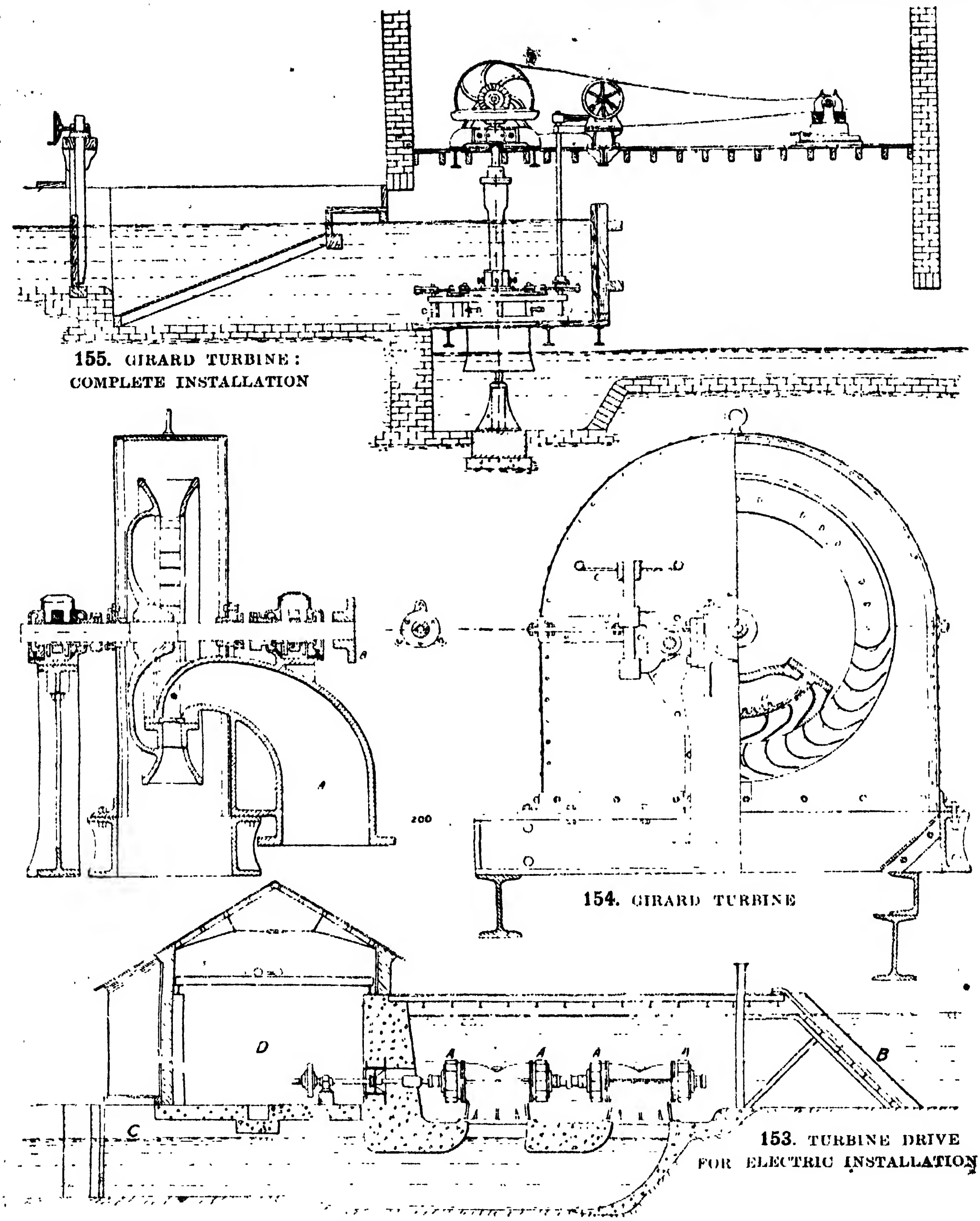
The Pelton Wheel. A water-wheel which is another connecting link between the gravity wheels and the turbines is the Pelton wheel. It is the best example of the impact wheel, pure and simple. A number of curved buckets are arranged around a disc, and a jet of water is driven through a nozzle against them under pressure. It utilises very low and very high falls, and also the force of the water pumped to a high pressure, as in the hydraulic power mains of cities. It is pre-eminently the water-wheel for high falls, being adaptable for working at any heads from about 20 to 2000 ft.; some installations exceed even this amount.

A great advantage of this wheel is its extreme simplicity of construction. A jet or jets of water are directed against the bucket, and slight variations in the dimensions of the tip of the nozzle, varying the volume directed against the buckets, render the wheels capable of working efficiently under varying water supplies. With low heads, large wheels with buckets of large capacity are required. The speed is determined by the head, but the diameter can be proportioned to speed required, and the number of nozzles can be increased to supply more water, or to obtain a higher speed than is obtainable by one nozzle.



152. THE FRANCIS TURBINE

Troubles of Turbines. Apart from these advantages, there is one fact that has more weight in some localities than in others. One of the troubles with turbines is the presence of leaves, sand, mud, etc., in the water, which chokes and scours the buckets; hence the need for the fitting of a grating or *forebay*, to intercept some



155. GIRARD TURBINE: COMPLETE INSTALLATION

154. GIRARD TURBINE

153. TURBINE DRIVE FOR ELECTRIC INSTALLATION

153–155. TURBINE INSTALLATIONS

of this injurious material. But the Pelton wheel, having open buckets only, discharges anything that comes in contact with them.

Fig. **181** illustrates a Pelton wheel installation for high falls by Messrs. Singrün Frères, of Epinal. It shows a device which is often fitted to these wheels—namely, two nozzles in place of one, so increasing speed. The governing mechanism and the sluice valve, the wheel covering, the tail race, and other details are apparent.

Turbines. The old, picturesque water-wheels beloved of artists have been largely displaced by the smaller turbines, which are submerged and invisible. The overshot wheel of large diameter, and the undershot wheel of Poncelet type, are the best, their efficiency nearly equalling that of turbines. But the breast wheels do not give more than half the efficiency of a poor turbine.

The water-wheel has its axis of rotation horizontal, and is a low-pressure motor. The turbine often has its axis of rotation vertical, and is a high-pressure motor. But there are some turbines with

horizontal axes, and there are also low-pressure turbines. Generally, water-wheels are gravity wheels. Turbines are either *reaction* wheels or *impulse* wheels. Besides this, they are classified according to the direction of entry of the water, as *inward flow, outward flow, axial*, and *mixed flow*. In all alike, water-wheels and turbines, the rotating wheel receives the water in buckets, blades, or vanes, by virtue of which the rotation is produced. The forms of these vary greatly, and slight differences in their curvature will often produce very important differences in efficiency.

Impulse and Reaction. It is now necessary to explain the difference between impulse and reaction turbines. The Pelton wheel [**131**] is an impulse wheel, and so, also, is an undershot water-wheel. Both these work in air. Yet there are impulse wheels which work entirely submerged in water, just as do the reaction or *drowned* turbines. The difference, however, is that the submerged impulse wheels have what are termed *ventilating* buckets, or buckets having openings to permit free access of air thereto. The practical advantages of the latter are apparent when varying and small quantities of water only are available. These, with others, to explain which would lead us too far afield into the technicalities of this branch of engineering, render impulse turbines of greater value in some cases than the reaction types. The prototype of the reaction turbine may be noted in Barker's mill. Here two jets of water issuing under pressure from bent tubes on opposite sides of a suspended tube cause rotary movement in a direction opposite to that in which the tubes are bent.

Water Flow in Turbines. Any turbine is distinguished from a water-wheel by having two rings of buckets or vanes, one ring containing guide vanes only, the other the buckets or the turbine proper. The function of the first is simply to bring the water at the most suitable angle into the latter, in order to produce the highest efficiency. The water may enter within the ring, and pass outwards, denoted by the term *outward flow*. Or it may enter from without, and pass away inwards, termed, then, *inward flow*. Or the water may pass through in a direction generally parallel with the axis of rotation —the *parallel*, or *axial flow*, group. Or the radial and parallel may be combined, as in the *mixed flow* turbines. Finally, the term *drowned* is applied to reaction turbines, and *ventilating* to the impulse kind. Each of these—the reaction and the ventilating—include the sub-divisions previously stated, as denoting the manner of flow, and each is, further, of low and high pressure classes.

The Fourneyron Turbine. Fig. **142** illustrates this, the oldest type of reaction turbine. It is of the outward flow class. The vanes and buckets are shown to the left, and a vertical section to the right. A is the fixed guide ring, through which the water flows to the turbine wheel B, so driving the latter round, and being itself deflected by the curves of the buckets before discharge on the outside of B. The sectional detail to the right shows three sets of vanes, and buckets, separated by plates, the object of which is the regulation of the quantity of water passing through. This is effected by sliding the governor ring C to one, two, or all three sets of openings. As shown, the openings are all covered.

The Girard Turbine. This is an impulse turbine. It is generally of the axial type. Its leading features are as follow. Fig. **143** illustrates vertical sections through the guide vanes and buckets with the hole *a* in the latter for ventilation. The water enters the vanes A with the entire velocity due to the head, and thrusts against the concave sides of the buckets B without touching the convex sides. To permit of this the buckets are widened towards the bottom.

The governing of the turbine is facilitated by the fact of its being an impulse type. A sliding gate, C, can be regulated to close the ports of the vanes or guides in succession. The ports not covered are thus left fully charged with water. Neither is there any change in the angle at which the water enters. It is, therefore, eminently suitable for cases where there is much variation in the water supply, or where the amount of water used shall be in direct proportion to the power required.

Girard turbines, as described, are used for falls of water up to about 50 ft. For higher heads, a system of partial injection is adopted, the water being admitted only on a portion of the circumferences. In this way a speed not too high is obtained, which with full injection would require reduction gears. Generally, too, the shafts in high fall turbines are set horizontally instead of vertically.

The Jonval Turbine. This, also, is of the parallel flow, or axial type, but it is a reaction or pressure turbine [**144**]. Its vanes, A, or *ports*, are closed, similarly to the Girard, by slides, not shown, for purposes of regulation. It is suitable for low and medium falls, and can be immersed in backwater, or raised above tailwater in a tail suction pipe, to a height not exceeding 25 ft.

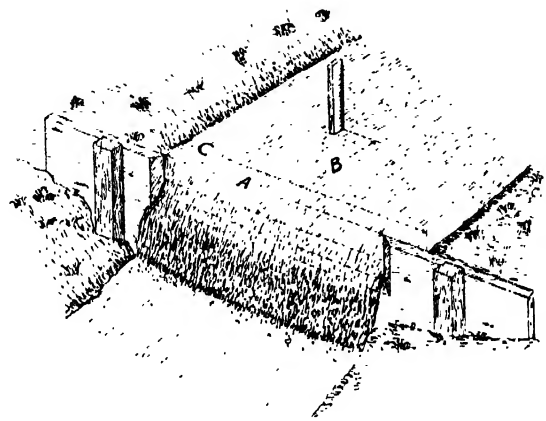
The Vortex. A turbine termed the *Vortex* is of the mixed flow type [**145**]. The water enters from the outside and passes away at the centre, below and above the casing. The wheel belongs to that class which has movable or adjustable guide passages, not illustrated, by virtue of which the supply of water to the buckets can be adjusted, so making the turbine capable of utilising reduced quantities of water in an economical fashion, since the water is admitted in any volume to the whole of the circumference of the wheel. The water supply comes through an encircling case. The width of opening of the nozzle of each guide blade is regulated simultaneously by means of levers and shafts, the blades being pivoted. There are four or more of these guide vanes in the circle. In cases where the quantity of water available and the power are constant, the guide vanes are fixed, since adjustability would have no advantages. This simplifies the construction.

The Leffel Turbine. This method of regulating the water supply by means of movable pivoted guide vanes is carried out in the Leffel turbines, and others modelled after them. Figs. **146** and **147** show this mechanism in sectional plan and in external plan respectively. The gates are operated from a central disc, A, which is moved by a pinion, B, and segmental rack, C. The levers seen pivoted to this disc regulate the amount of opening of the gates D. A fender opposite each gate relieves it of the pressure due to head of water, so that it can be moved readily.

Fig. **148** shows an improved form of wheel brought out by the Leffel Company, which they have christened the *Samson*. It is a double wheel, retaining the gates, not shown, of **147**. Each set of buckets receives its own quantity of water.

The Little Giant. This turbine is of the mixed flow type. The water enters radially from without, and discharges axially. But the water enters into two sets of vanes, divided by a partition, and escapes through two sets at top and bottom

[149 and 150]. These stand out from the sides of the wheel very much like cowls. It may, therefore, be described as a double turbine in one casing, the upper tier of buckets discharging at the top, and the lower tier at the bottom of the case. This turbine is well adapted for part gate working, or for those conditions in which the water supply is variable, and deficient in amount in dry weather. Regulation is effected by an iron division plate that passes horizontally through the turbine casing, and divides it into two compartments, corresponding with the two tiers of buckets. The water supply is regulated by a sliding gate which admits the water to both tiers of buckets, or to the lower tier only, according to whether it comes down to the division plate or not. The point to note is that the full pressure is maintained in the lower bucket, so that the efficiency is as high in proportion as when working at full gate, which would not be the case but for the division into two sets of buckets. It is of the drowned type, the tops of the upper buckets being about 3 in. below the surfac of the water in the turbine pit.



156. FINDING QUANTITY OF WATER IN MOTION

The Hercules Turbine. This turbine, the wheel of which is shown in **151**, is of the mixed flow class, inward and downward. It is of the regulating type, a cylindrical gate between the guide passages, and wheel opens or closes the rows of buckets. It is a reaction wheel.

The Francis Turbine. This is an old type, which has suffered from neglect until recent years. It has been revived, notably by the Swiss firm of Escher Wyss & Co., and the finest installations of this type are those of the Niagara Falls Power Company and the Canadian Company. In the former, there are ten of these turbines of 5500 h.p. each. In the latter, the turbines, three in number, are of 10,250 h.p. each.

The combination of radial and axial flow with the curvature of the va .es, which causes the water to leave them in a direction parallel with the axis, is the secret of efficiency. The point is that the radial flow is changed into the axial while the water is in the buckets, instead of after it has left them. In the latter case there would be kinetic energy still in the water, which means waste. Fig. **152** sh. ws two Francis turbines on one shaft.

Girard Turbine Plant. Fig. **154** illustrates a Girard turbine by Messrs. Gilbert Gilkes & Co., Ltd., from which a very good idea may be gathered of the mechanical details of construction. It is of the same type as the buckets shown in **143**, and is, therefore, an impulse turbine. The inlet pipe is seen at A, and the shaft is horizontal, and therefore a dynamo can be directly attached to the coupling B. C is the handle for regulating the gate D.

Fig. **155** shows a complete installation by the same firm. The turbine has a vertical shaft with a suspended form of bearing—a design which is largely displacing the old footstep bearing. Here the drive is through bevel gears and belt to the dynamo seen at the extreme right. The levels of the head and tail waters are evident, and also the forebay or strainer to the left, and the regulating sluice immediately in front of it. The regulating mechanism for the gates is seen to the right of the turbine, operated by a hand wheel at the top. The brick linings, timber frames, and timber and steel joists, with other details, are apparent.

Advantages of Turbines. The story of the turbine, like many another piece of engineering, is one of development. The old Fourneyron, of sixty-five years ago, was a wonderful machine. The most successful machine of the present day is, in a sense, a Fourneyron reversed. The Francis is a radial inward - flow turbine, the fixed guide wheel surrounding the movable wheel. Turbines may be single, double, treble, or quadruple, with corresponding increase of speed. A great advantage which the turbine has over a water-wheel is that its axis can be set horizontally just as easily as vertically. It is a question of bringing in the water. This question has assumed great importance since the practice of coupling dynamos direct to turbine shafts has become so general. This is impossible with a common water-wheel, because the speed of revolution is never high enough for electric driving. Dynamos are coupled to vertical shafts, but it is preferable to have the shafts horizontal when practicable. Fig. **153** illustrates a turbine drive for an electric installation. Here there are four turbines, A, A, A, A, driving on one horizontal shaft.

The objection to placing the axis of a turbine vertically is the difficulty of supporting the central revolving shaft in a suitable bearing. Another is that this position is not so suitable for direct driving of dynamos and shafting as the horizontal. Hence the reason why very many turbines have their shafts horizontal, as in **153**, running in good bearings, and coupled direct to dynamos or belted to machinery.

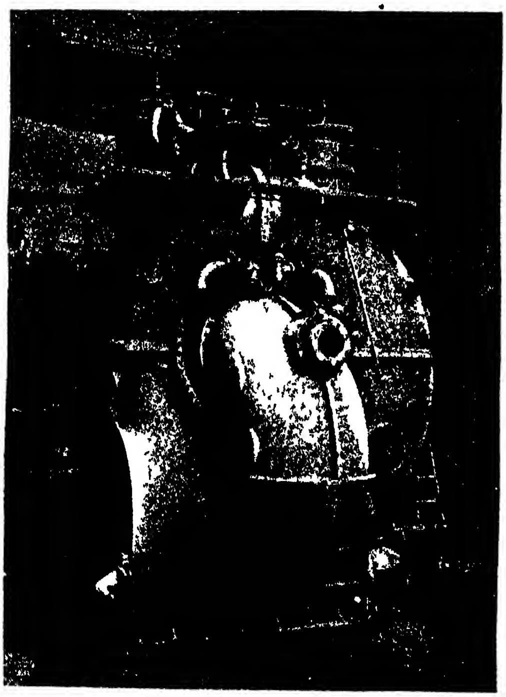
Water and Electricity. The potentialities of water power have been utilised to a far greater extent since the installations of electricity have come into existence. There are hundreds of thousands of horse-power which could not have been enchained without the electric conductor as an agent of transmission to distant industries. In Canada, the United States, California, Switzerland, and Italy, France, Germany, Sweden, and other lands, rivers and falls which have run to waste for thousands of years have, within the last ten years, been made to supply electric light and power. Gradually the distances of transmission have increased, until the 200-mile limit has been passed, and engineers now talk of 500-mile, and even greater, possibilities.

Water power has the advantage of being the cheapest power agency. It will give back from 70 to 80 per cent. of work, against, say, the 20 to 25 per cent. of steam-engines and 30 per cent. of gas-engines. The limitations to distance no longer

exist, as they did in the old days when belts and ropes afforded the only means of transmission.

Large and Small Water Supplies. There is no difficulty in dealing with a constant and large flow of water. Even efficient water-wheels can be constructed for such conditions. It is when the fall is low and the volume small, and also variable, that the hydraulic engineer has to weigh well the relative merits of reaction and of impulse turbines. Many weighty considerations are involved, one of the principal of which is the problem of getting a turbine that will work satisfactorily at *part gate*, as it is termed. Another is the question of speed. The higher the fall, the smaller is the turbine, and the higher its rate of revolution.

With low falls the turbines must be of larger radii, and they revolve more slowly. Then the question of the nature of the work they have to do must be considered. A high speed would be desirable in some cases, such as for driving dynamos, but for slow running machinery a slowly running turbine is preferable to reduction gear. But a large turbine costs more than a small one, and, being heavier, entails losses by friction. Hence there is no one type of turbine which is adaptable to all



157. AN ENORMOUS TURBINE

conditions, and there is, as the present article shows, a wide range of choice, so that an engineer who understands his work can always, knowing the governing conditions, advise as to the best for any given case.

Turbine Economy. An important feature in turbine economy is the governing of the speed and power. To use more water than is necessary is wasteful, besides which speed must not exceed required limits. In water-wheels the supply is regulated by a gate in the head race, and the height of this, again, is under the control of a speed governor. In drowned or reaction turbines it is necessary that the buckets be full of water.

England is not a land of turbines, nor is she ever likely to be, because conditions are not so favourable as are those of more mountainous countries. Low falls, little head, and variations in quantity in winter and summer are not favourable to turbine driving. If there is a reasonable head, there is little water; if there is a flood, there is little head.

Horse-power. To find the horse-power of water in motion, multiply the quantity of water in cubic feet per minute by the weight of a cubic foot - $62\frac{1}{2}$ lb., and by the height of the fall in feet, and divide the product by 33,000. This is only the theoretical power. Of this a good turbine will utilise 75 to 80 per cent., and water-wheels, the breast type excepted, from 50 to 60 per cent. The height is measured from the level of the water in the head race to the level of the water in the tail race. Another method of reckoning the power of water is that used in California and termed the *miner's inch*. It denotes the quantity of water that will flow in a minute from an orifice 1 in. square under a head of 6 in., and is equal to $71\frac{1}{2}$ cubic ft. per minute. Tables are prepared based on this. The quantity of water in cubic feet is measured by a notched board set across the stream as follows.

A length of from 50 to 100 ft. is selected, as uniform in section as possible, and its area of section is obtained by multiplying the average width by the average depth. A stake is driven at each end of the length selected, a float thrown into the middle of the stream a little above the first stake, and note is made of the exact time it occupies in passing from one stake to the other. This should be repeated several times to obtain the average speed. A bottle partly filled with water to float upright, or a piece of wood, are suitable floats.

To find the quantity of water passing, the sectional area of the stream is then multiplied by the length taken, and by 60, and divided by the time taken in seconds by the float in passing over the measured length. A deduction must be made for loss due to friction at the bottom and sides of the stream, which may be taken at about 20 per cent.

Notched Board Measurements. Another method is that of a notched board, or tumbling bay, [156] placed across the stream to pass a given quantity of water over the notch, so forming a weir. The notch may be of any depth, but the lower level of the water should be at least a foot below the bottom of the notch. Its width, A, is about two-thirds the width of the stream, C. The bottom of the notch in the dam must be level. The dam should be of sufficient height to produce a still reach of stream above, so that the water shall flow over without appreciable velocity. A stake is driven near the bank for convenience in taking measurements. It must be far enough up the stream, B, to be unaffected by the curvature of the surface of the water passing over the weir, say, 6 feet. The edges of the notched board are bevelled on the down side to nearly a sharp edge. When the dam is placed in position, and the water obstructed thereby, the height to which the water rises up the stake indicates the depth of water flowing over the weir. When the water has ceased to rise above the weir, the depth from the surface to the top of the stake is measured. The width and depth are the data from which the quantity of water in cubic feet per minute are obtained from weir tables.

J. G. HORNER

French: Indefinite Adjectives. German: The Strong Declension of Nouns. Spanish: The Imperative Mood and the Adverb.

FRENCH

Continued from page 1976

By Louis A. Barbé, B.A.

INDEFINITE ADJECTIVES

The indefinite adjectives are *aucun*, no ; *nul*, no ; *chaque*, each ; *même*, same, self ; *tout*, all ; *quelque*, some ; *plusieurs*, several ; *tel*, such, such a ; *maint*, many a ; *quel*, what.

(*a*) *Aucun* and *nul*, no, are negative, and therefore require *ne* before the verb of which they are either subjects or objects.

They are both singular :

Aucun chemin de fleurs ne conduit à la gloire, no path of flowers leads to glory.

Il n'a aucun emploi, he has no employment.

Nul homme n'est exempt de la mort, no man is exempted from death.

Je n'ai nulle autorité, I have no authority.

(*b*) *Chaque*, each, can only be used in the singular :

Chaque âge a ses plaisirs, each age has its pleasures.

(*c*) *Même* means "same" when it precedes a noun. It means "self" when it follows a pronoun, and is joined to it by a hyphen :

Ils ont les mêmes droits, they have the same rights.

Vous êtes contents de vous-mêmes, you are pleased with yourselves.

(*d*) *Tout*, all, has a feminine form, *toute*, and the plural forms *tous*, for the masculine, and *toutes* for the feminine. It takes the definite article, and is the only adjective that precedes it. A possessive may take the place of the article :

Tout son pouvoir, toute sa capacité, toutes ses forces, tous ses efforts, all his power, all his capacity, all his strength, all his efforts.

In the plural it has the meaning of "every" :

Tous les jours, every day.

When used in the singular, and without the article, it has the same meaning :

Tout citoyen a des devoirs aussi bien que des droits, every citizen has duties as well as rights.

Tout, tous, toutes, may not, like the English *all*, immediately precede a relative pronoun. The singular must be followed by *ce*, and the plural by *ceux* or *celles* : *Tout ce qui reluit n'est pas or*, all that glitters is not gold ; *tous ceux qui le connaissent le respectent*, all who know him respect him. *Tous* may not come immediately after a personal pronoun : We all know him, *nous le connaissons tous*.

(*e*) *Quelque*, and its plural, *quelques*, mean "some," but are more restricted in sense than the partitive :

Nous avons eu quelque difficulté, we have had some (a little) difficulty.

J'ai quelques bons livres, I have some (a few) good books.

(*f*) *Plusieurs*, several, has only one form for both masculine and feminine :

Plusieurs historiens, plusieurs histoires, several historians, several histories.

(*g*) *Tel, telle*, such, are usually preceded by *un*, or *une*, and their plurals, *tels, telles*, by *de* :

Un homme d'un tel orgueil est insupportable, a man of such pride is unbearable.

Il n'y a pas de tels animaux, there are no such animals.

The indefinite article never comes after *tel*, as it does after "such" in English :

Un tel homme est insupportable, such a man is unbearable.

"Such" before an adjective is *si*, used in connection with *un, une*, for the singular, and with *de* for the plural :

Un homme si intelligent, such an intelligent man.

Une si belle maison, such a fine house.

Des hommes si courageux, such brave men.

De si gentils enfants, such nice children.

Tel repeated before two nouns, and used without an article, means "like" :

Tel maître, tel valet, like master, like man.

(*h*) *Maint, mainte* is equivalent to the English "many a," but may be used in the plural :

Avec quelques vertus il a maint et maint défaut together with a few virtues he has many and many a defect.

Maintes fois, or *mainte fois*, many a time

Quel, what, is used in both direct and indirect questions :

Quel livre lisez-vous ? What book are you reading ?

Quelle heure est-il ? What time (hour) is it ?

Je ne sais pas quelle heure il est, I do not know what time it is.

The names of countries take the definite article except after the preposition *en*, and after the preposition *de* when, with its aid, they form adjectival expressions : *la France, en France*, but *du cuir de Russie*, Russian leather. Before feminine names of countries *in* is rendered by *en* ; before names of towns it is rendered by *à* ; *je demeure à Paris*, I live in Paris ; *Paris est en France*, Paris is in France.

EXERCISE XIV.

VOCABULARY.

âge (m.), age
an (m.), year
argent (m.), silver
armée (f.), army
Ascension (f.), Ascension
Assomption (f.), Assumption
la Bastille, Bastille
la Belgique, Belgium
la capitale, capital
la chute de pluie, rainfall
le centime, centime
le centimètre, centimetre
le chemin de fer, railway

le climat, climate
le commerce, commerce
le degré, degree
le département, department
la distance, distance
la durée, duration
effectif (m.), effective, strength
exportation (f.), exportation
la fête, feast
le franc, franc
la France, France
le globe, globe
habitant (m.), inhabitant
importation (f.), importation
industrie (f.), industry
le jour, day
le jour de l'An, New Year's day
le kilomètre, kilometre
la ligne, line
la Loire, Loire
la longueur, length
la marine, navy
le matelot, sailor
la mémoire, memory
le mille, mile
le navire de guerre, warship
Noël (m.), Christmas
Or (m.), gold
la paix, peace
la partie, part
Pâques (m.), Easter
la Pentecôte, Whitsunday, Pentecost
la période, period
la pièce, piece (of money)
la pluie, rain
la population, population
le port, harbour
le pouvoir, power
le président, president
la prise, taking, capture
la république, republic
la réserve, reserve
la rivière, river
le service, service
le soldat de marine, marine
la Suisse, Switzerland
la superficie, area
la température, temperature
le temps, time
le territoire, territory
la tête, head
la Toussaint, All Saints
la valeur, value
la ville, town

actif, active
anglais, English
annuel, annual
carré, square
commercial, commercial
considérable, considerable
exécutif, executive
extérieur, exterior, foreign
français, French
important, important
juif, Jewish, Jew
long, long
militaire, military
mobile, movable
moyen, mean, average
national, national
obligatoire, obligatory, compulsory
protestant, protestant
tempéré, temperate
territorial, territorial
total, total
célébrer, to celebrate
former, to form
indiquer, to indicate
monter, to man
placer, to place
tomber, to fall
mesurer, to measure, reckon
comprend, comprises
vaut, is worth
élu, elected
à peu près, about, nearly
après, after
dès, from, beginning with
entre, between
en, in
par, by
Paris, Paris
environ, about, nearly
tard, late
c'est-à-dire, that is to say
pour, for
ensemble, together
Lyon, Lyons
Marseille, Marseilles

Translate into French

The territory of the French Republic is about 536,500 square kilometres. Its area is nearly thirteen times the area of Switzerland, and more than thirteen times the area of Belgium. Its population is 39,600,000 inhabitants. It has 86 departments. Its climate is temperate; its mean yearly temperature is 60 degrees. Its rainfall is 80 centimetres. France forms a republic. At the head of the executive power is placed the President of the Republic. He is elected for a period of seven years. Military service is compulsory in France from the age of 20. The duration of the service is 25 years: two years in the active army, 11 years in the reserve of the active army, six years in the territorial army, and six years in the reserve of the territorial army. In time of peace the effective strength is about 560,000 men. The French navy comprises 450 ships of war. They are manned by about 100,000 sailors and marines. There are five great military ports. Paris, the capital of France, has a population of about 3 millions. Lyons and Marseilles are also two of the largest towns in France. In Marseilles there are 550,600 inhabitants; in Lyons there are 523,800. Paris has more than 1,800,000 inhabitants more than those two towns together. By its industries and its commerce Paris is one of the first towns in the world. Marseilles is the first harbour in all the Mediterranean, and one of the 10 or 12 most important commercial places of the globe. The commerce of France is very considerable. The average value of its foreign trade is 12,500,000,000 or 12½ "milliards"; 6 of importation and 6½ of exportation. The longest river in France is the Loire. The length of the Loire is 1020 kilometres. The railway lines of France have a total length of 48,000 kilometres. The English measure distances by miles; the French by kilometres. The English mile is 1609 metres. The French indicate value by francs and centimes. The franc is worth a little less than 10 English "pence." The centime is the 100th part of the franc. There are pieces of silver of 50 centimes and gold pieces of 10 francs. The largest silver piece is the 5-franc piece. In France the feast days are: the 1st of January, or New Year's day, Easter, the Ascension, Pentecost, the Assumption, All Saints, and Christmas Day. All Saints is always the 1st of November, and Christmas the 25th of December. Easter falls between the 21st of March and the 26th of April. The Ascension is also a movable feast. It falls 40 days after Easter. Pentecost falls 10 days later—that is to say, 50 days after Easter. The French celebrate their national feast (on) the 14th of July, in memory of the taking of the Bastille in 1789.

[K]ey to Exercise XIII (page 1975)

1. Nous avons passé une quinzaine de jours à Londres.
2. J'ai acheté une demi-livre de beurre et une demi-douzaine d'œufs.
3. Dans quatre-vingt-dix-sept il y a neuf dizaines et sept unités.
4. Il y a une centaine de pages dans le cahier.
5. Quelle heure est-il? Il est quatre heures dix; dans cinq minutes il sera quatre heures et quart, et dans vingt minutes il sera quatre heures et demie.
6. Cette rue a un demi-mille de longueur (long) et cinquante pieds de largeur (large).
7. Notre maison a plus de quarante pieds de hauteur (haut).

8. Cette table a deux mètres de long sur un mètre soixante-quinze centimètres de large.

9. Vous avez trois fautes; je n'en ai qu' une.

10. Douvres est à environ vingt et un milles de Calais.

11. Le Pas de Calais a plus de vingt milles de large.

12. Vous avez gagné plus de cinquante francs de plus que nous.

Continued

GERMAN

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By P. G. Konody and Dr. Osten

XXVII. If the Possessive Pronoun [see XVII.] is not directly connected with its substantive by preceding it, it either takes (*a*) the definite article and follows the *weak* declension of the adjectives [see XXVI., 1], or (*b*) it remains without article and takes the inflections of the *strong* declension [see XXVI., 2].

Examples. Preceding the substantive: mein Hut (*m.*), my hat; meine Weſte, (*f.*), my waistcoat; mein Hemd (*n.*), my shirt. (*a*) The pronoun takes the article and follows the substantive: Der Hut iſt der mein-e, the hat is mine; die Weſte iſt die mein-e; das Hemd iſt das mein-e. [There is also a lengthened form with the inserted suffix ig: der mein-ig-e, die mein-ig-e, das mein-ig-e.] (*b*) Without article: dieſer Hut iſt mein-er, dieſe Weſte iſt mein-e, dieſes Hemd iſt mein-es.

1. This declension of the adjectives (*a*) the weak, and (*b*) the strong, is applied to all disjoined possessive pronouns: mein, dein, ſein, ihr, unſer, euer, ihr—*e.g.*: dieſer Hut iſt der ſein-e, der ſein-ig-e, and dieſer Hut iſt ſein-er; dieſes Buch iſt das unſ(e)r-e, das unſ(e)r-ig-e, and dieſes Buch iſt unſer-es. The *strong* inflection is sometimes dropped after the auxiliary verb ſein: dieſer Hut iſt mein-er, and dieſer Hut iſt mein(er).

2. The possessive pronoun used with the definite article takes a capital when used substantively: Ich habe das Meine (or das Meinige) getan, I have done [the] mine (my duty, all I could do). Jedem das Seine (or Seinige), to everyone [the] his (his due); etc.

XXVIII. The prefix ge (see XIV.) cannot be used for the formation of the past participle of verbs with *unstressed* first syllables, such as the verbs with the unstressed prefixes be, emp, ent, er, ge, ver, and zer. These unstressed particles which, detached from the verb, convey no meaning, cannot therefore be disjoined, and are called inseparable prefixes, to distinguish them from the separable prefixes, to which belong the prepositions and adverbs which have also an independent existence. When joined to the verb these separable prefixes are *stressed*. They can be detached from the verb and displaced in the course of conjugation.

1. Verbs with separable stressed prefixes ab, an, auf, aus, bei, hin, mit, um, etc., form their past participle by insertion of the conjugational prefix ge between the stressed prefix and the stem, and by the addition of et or t to the stem of weak verbs [see XIV.], and en or n to the stem of strong verbs, with unchanged or changed vowels [see XVIII.]—*e. g.*: the *weak* verb ſtell-en (to put, to place), joined to the separable *stressed* prefix aus (out) aus′-ſtell-en (to exhibit, expose), forms the past participle: aus′-ge-ſtell-t. The verb entſtel′-len (to disfigure, to deform) with the *unstressed* prefix ent, forms the past participle: entſtellt′ without the prefix ge. The *strong* verb ſchreib-en, to write (imperfect: ſchrieb, with change of vowel: past participle: ge-ſchrieb-en [see XVIII.]), when joined to the *stressed* separable prefix ab (off, from) = ab′-ſchreib-en (to copy), forms the past participle: ab-ge-ſchrieb-en. On the other hand, beſchrei′ben, to describe, with the *unstressed* inseparable prefix be, forms the past participle: be-ſchrie′b-en. The past participle always forms *one* word: aus′geſtellt, entſtellt′, geſchrie′ben, ab′geſchrieben, beſchrie′ben.

2. In the *present, imperfect*, and *imperative* the stressed separable prefixes are completely detached from, and placed behind, their verbs: ab′ſchreiben, present indicative: ich ſchreib-e ab, etc.; present conjunctive: ich ſchrieb-e ab, etc.; imperfect indicative: ich ſchrieb ab, etc.; imperfect conjunctive: ich ſchrieb-e ab; imperative, singular 2: ſchreib-e ab! ſchreib-en Sie ab! plural 2: ſchreib-et ab! In the present and imperfect the prefix is placed at the end of the clause or sentence; present: Ich ſchreib-e den Brief ab, I copy the letter; imperfect: ich ſchrieb den Brief ab, I copied the letter, but perfect: ich habe den Brief ab′-ge-ſchrieb-en; pluperfect: ich hatte den Brief ab′-ge-ſchrieb-en; first future: ich werde den Brief ab′ſchreiben, I shall copy the letter; second future: ich werde den Brief ab′geſchrieben haben, I shall have copied the letter.

3. In principal clauses like the above the *constant forms* (past participle and infinitive of the verbs [see XXIV.]) are placed at the end and are separated from the *finite forms* by the objects of the actions, etc. Where both constant forms are used, the infinitive is placed at the end. Examples: Der Lehrer lobte den Schüler, the teacher praised the pupil; der Lehrer hat [finite verb] den Schüler gelobt [past participle], the teacher has praised the pupil; and der Lehrer wird [finite verb] den Schüler gelobt [past participle] haben [infinitive], the teacher will have praised the pupil. Note the difference in the position of the words in the two languages. Literally translated, the German sentence would run: the teacher will the pupil praised have.

XXIX. The Strong Declension of Substantives. Refer to Table B, page 650.

1. The unaltered plural (first case) [see Table B, 2, 5] is only formed by *masculine* and *neuter* substantives.

2. The plural with modification of the vowel and no other change [see Table B, 8] is formed chiefly by *masculines*, by the feminines die Mutter and die Tochter, and the neuter das Kloſter, the cloister, convent (plural: die Mütter, die Töchter, die Klöſter). The plural of the neuter das Waſſer,

the water, is die Wasser or die Wasser, the latter being preferable.

3. The e in the plural without modification of the vowel [see Table B, 6] is chiefly taken (a) by *masculines* and *neuters*, and only by such *feminines* as end in sal and nis, and substantives of foreign origin ending in an unstressed as, is, nis, os, us. The latter and all substantives ending in nis double the final s. Examples: die Trübsal (the affliction), die Trübsal-e; die Wild'nis (the wilderness), die Wildniſſ-e; die A'nanas (the pineapple), die A'nanaſſ-e; der Fir'nis (the varnish), die Firniſſ-e; der Iltis (the polecat), die Iltiſſ-e; das Rhino'zeros (the rhinoceros), die Rhino'zeroſſ-e; der Re'bus (picture-puzzle), die Re'buſſ-e.

(b) Substantives with a final (round) s change it in the plural (with suffix e) into the long *soft* form (ſ), pronounced as in Roſe. Examples: der Greis (the old man, greybeard), die Greiſ-e; das Los (the lot, lottery-ticket), die Loſ-e.

(c) Substantives ending in ß preceded by a long vowel retain both in the plural: das Maß (the measure), die Maß-e; der Schweiß (the sweat), die Schweiß-e. In those with short vowels the ß changes in the plural into ſſ: das Roß (the horse), die Roſſe, etc.; the same change occurs with nouns of foreign derivation ending in an *unstressed* syllable with a final ß: der Kom'paß (the compass), die Kom'paſſ-e, der Kü'raß (the cuirass), die Kü'raſſ-e, etc.

4. The plural with the suffix e and modification of the vowel [see Table B, 7] is formed mainly by *masculines*, and by most of the feminines belonging to the strong declension [chiefly monosyllabics]. The only neuters that take this plural are das Chor (the choir), die Chör-e, and das Floß (the float), die Flöß-e; but it must be remembered that the masculine gender is optional for these two nouns.

5. The plural er [see Table B, 4] is formed chiefly by *neuters*, and by a few *masculines*, never by feminines. The modifiable vowels are modified. Examples: der Geist (the spirit), die Geist-er; das Nest (the nest), die Nest-er; das Gemüt' (the soul), die Gemüt-er; das Ei (the egg), die Ei-er; das Bild (the picture), die Bild-er; der Wald (the forest), die Wäld-er; der Rand (the border), die Ränd-er; das Loch (the hole), die Löch-er; das Buch (the book), die Büch-er; das Haupt (the head, chief), die Häupt-er; etc.

6. The plural with s [see Table B, 9] is formed by substantives of foreign origin (French, English, etc). Examples: der Chef (the chief), die Chef-s; der Salon (the drawing-room), die Salon-s, der Jockey, die Jockey-s; der Papa, die Papa-s; etc. A few German words take the same plural in vernacular: der Junge (the boy, youth), die Jungen-s [correct form: die Jungen]; der Kerl (the fellow), die Kerl-s [correct: die Kerle]; das Mädel (the lass), die Mädel-s [correct: die Mädel]; das Fräulein (the young lady), die Fräulein-s [correct: die Fräulein].

XXX. The rules of paragraph XXIX., 3 *b*, c, are also applicable to the declension of the singular (strong genitive with es or s, etc.).

EXAMPLES:

1. der Greis, 2. des Greiſ-es, 3. dem Greiſ-e, etc.
1. das Los, 2. des Loſ-es, 3. dem Loſ-e, etc.
1. das Maß, 2. des Maß-es, 3. dem Maß-e, etc.
1. das Roß, 2. des Roſſ-es, 3. dem Roſſ-e, etc.
1. das Geheim'nis (the secret), 2. des Geheim'niſſ-es, 3. dem Geheim'niſſ-e, etc.
1. der Il'tis, 2. des Iltiſſ-es, etc.
1. der Kompaß, 2. des Kompaſſ-es, etc.
1. der Küraß, 2. des Küraſſ-es, etc.

EXAMINATION PAPER

1. Which declension is followed by the possessive pronoun not directly preceding the qualified substantive?
2. What classes of prefixes are known in German verbs, and how do they differ as regards stress and meaning?
3. To which class of nouns do some of the separable prefixes belong?
4. How do verbs with stressed prefixes form the past participle?
5. In which tenses are the stressed prefixes detached from their stems, and where are they placed?
6. What is the arrangement of the constituents of a compound tense (finite verb, past participle, and infinitive) in a German sentence?
7. Of which gender are the strong substantives which undergo no alteration in the nominative plural, and how can the plural be distinguished from the singular?
8. To which gender belong most of the substantives which modify their stem-vowel in the plural without taking a suffix?
9. Which feminine nouns take in the plural the suffix e with, and which without, modification of the stem-vowel?
10. Of which gender are the nouns that form the plural by the suffix er without, and with, modification of the stem-vowel?
11. How is the plural sounded in nouns with a final (round) s in the singular [das Los], and what alteration does the final ß undergo in the plural, when preceded by a long or by a short vowel?
12. Which nouns take the suffix s in the plural?

EXERCISE 1. Insert the missing declensive inflections

(*a*) Der Griff meines Stockes (*m.*) ist schön;
The handle of my stick is beautiful;
ich gab mein . . . Freunde (*m.*) dein . . Stock (*m.*);
I gave to my friend thy stick,
sie brach ihr . Uhr (*f.*); der Deckel (*m.*) ihr . . Uhr (*f.*)
she broke her watch; the cover of her watch
ist zerbrochen; er fuhr mit (3) sein . . und mit (3) ihr . .
is broken; he drove with his and with her
Pferden (*n.*); ich ging zu (3) Ihr . . Ärzte (*m.*); sie
horses; I went to your physician; they
gingen mit (3) ihr . . Eltern in (4) unser . . . Garten (*m.*)
went with their parents into our garden
und bewunderten die Schönheit (*f.*) unser . . Blumen (*f.*).
and admired the beauty of our flowers.
Eu(e)r . . . Freunde (*m.*) und die Brüder (*m.*) eu(e)r . . .
Your (*pl.*) friends and the brothers of your
Freunde (*m.*) waren in (3) eu(e)r . . Garten (*m.*) und
friends were in your garden and
pflückten eu(e)r . . Blumen (*f.*)
gathered your flowers,

(*b*) Ihr Freund (*m*) ist auch der mein . . (*or* unser .);
Your (*sing*) friend is also mine (*or* ours);

er brach nicht blos sein.. Uhr (*f.*), sondern auch
he broke not only his watch but also
die dein.., die ihr.., die uns(e)r.., die eu(e)r.., die ihr..
thine, hers, ours, yours, theirs.
und die Ihr..; die Schnelligkeit dein... Hengstes
and yours; the speed of thy stallion
ist größer als die des mein.., des sein.., des ihr..,
is greater than that of mine, of his, of hers,
des uns(e)r.., des eu(e)r.., des ihr.. des Ihr...;
of ours, of yours, of theirs, of yours;
seine Dogge (*f.*) lief hinter (3) der mein.., der dein..,
his bulldog ran behind mine, thine,
der ihr.., der uns(e)r.., der eu(e)r.., der ihr.., der Ihr..;
hers, ours, yours, theirs, yours;
mein Pferd schlägt das dein.., das sein.., das ihr..,
my horse beats thine, his, hers,
das eu(e)r.., das ihr.., das Ihr..; deine Freundinnen (*f.*)
yours, theirs, yours; your friends (*f.*)
sind auch die uns(e)r.., die ihr... Die Wolle mein..
are also ours, theirs. The wool of my
Schirmes (*m.*) ist besser als die Seide des dein..,
umbrella is better than the silk of thine,
des sein.., des ihr.., des uns(e)r.., des eu(e)r..,
of his, of hers, of ours, of yours,
des ihr.., des Ihr..; ich glaube dein... Freunde (*m.*)
of theirs, of yours; I believe (to) thy friend (3)
mehr als dem mein.., dem sein.., dem ihr..,
more than mine, his, hers,
dem uns(e)r.., dem eu(e)r.., dem ihr.., dem Ihr..;
ours, yours, theirs, yours;
er liebt sein.. Freund (*m.*) mehr als den mein..,
he loves his friend more than mine,
den dein.., den ihr.., den uns(e)r.., den eu(e)r..,
thine, hers, ours, yours,
den ihr.., den Ihr.. etc.
theirs, yours, etc.

(*c*) der Stock (*m.*), die Dogge (*f.*), das Pferd (*n.*) ist
the stick, the bulldog, the horse is
mein.., dein.., sein.., ihr.., uns(e)r.., eu(e)r..,
mine, thine, his, hers, ours, yours,
ihr.., Ihr..
theirs, yours.

(*d*) Replace the possessive pronouns in (*b*) by their lengthened form, whenever this form is applicable.

EXERCISE 2. (*a*) Form the present indicative in all persons and both numbers of the following verbs with *stressed separable* prefixes: aufstehen, to rise; anbieten, to offer; ausgeben, to spend; beischließen, to enclose; einschlafen, to fall asleep; hinkommen, to get there; mitnehmen, to take along with; umfallen, to fall [down].

(*b*) Form the *present* tense of the following *strong* verbs with *unstressed* inseparable and *stressed* separable prefixes, the stress marked by an apostrophe *behind* the stressed syllable: ver-ste'hen, to understand; bei-'stehen, to assist; ver-bie'ten, to forbid; auf-'bieten, to call up, to summon; aus-'schließen, to exclude; be-schlie'ßen, to resolve, (finish); ge-fal'len, to please; auf-'fallen, to fall upon (also in the sense of: "to be conspicuous").

(*c*) Form the *imperative* singular and plural in the ordinary and civil form of address of the verbs enumerated in (*a*) and (*b*).

EXERCISE 3. Change the *present* tense of the following *weak* verbs [see XXIV.] for the *perfect* and *pluperfect* in the arrangement explained in XXVIII., 3; [the verbs conjugated with the auxiliary verb of tense s e i n (to be) are made prominent in print, all others are conjugated with h a b e n (to have)]:

Der Schüler lernt; der Lehrer öffnet das Fenster;
The pupil learns; the teacher opens the window;
der Künstler zeichnet ein Bild; das Mädchen lächelt;
the artist draws a picture; the girl smiles;
der Gärtner arbeitet im (3) Garten; das Schiff s e g e l t;
the gardener works in the garden; the ship sails;
die Kinder spielen; die Mädchen e r r ö t e n; ich liebe
the children play; the girls blush; I love
meine Eltern; er redet Unsinn; du rauchst eine
my parents; he talks nonsense; thou smokest a
Cigarre; ihr badet im (3) Flusse; sie läuten die Glocke;
cigar; you bathe in the river; they ring the bell;
die Kinder zerstören ihr Spielzeug; er lauscht an (3) der
the children destroy their toys; he listens at the
Türe. du begrüßest den Vater.
door; you greet the father.

EXERCISE 4. Form the *plural* (*a*) [without Inflection] of the following substantives, of which those with *modifiable* vowels in the stressed syllable are modified: der Va'ter (*m.*), the father; der Löf'fel (*m.*), the spoon; der Ap'fel (*m.*), the apple; das Fen'ster (*n.*), the window; der E'sel, the donkey; der Bru'der, the brother; der On'kel, the uncle; der Vo'gel, the bird; der Rei'ter, the horseman; der Fa'den, the thread; das Veil'chen, the violet; der Käse, the cheese; der Sattel, the saddle; (*b*) of the following substantives (following XXIX., 3): der Berg, the mountain; der Hund, the dog; das Jahr, the year; die Kennt'nis, the knowledge; der Hirsch, the stag; die Bewandt'nis, the condition, state; das Pferd, the horse; das Haar, the hair; der Kür'bis, the pumpkin; das Lab'sal, the refreshment; der A'bend, the evening; der Preis, the prize; das Moos, the moss; das Fließ, the fleece; der Schuh, the shoe; der Sproß, the offspring; das Geheim'nis, the secret; (*c*) of the substantives following the rules of XXIX., 4: der Arzt, the physician; die Gans, the goose; der Kopf, the head; die Braut, the bride; die Hand, the hand; der Zahn, the tooth; der Topf, the pot; die Faust, the fist; der Fuchs, the fox; die Brust, the breast; der Strom, the stream; die Wurst, the sausage; der Krug, the jug; (*d*) of the substantives following XXIX., 5: das Tuch, the cloth; das Land, the country; das Kind, the child; das Gewand, the garment; das Weib, the woman; das Kraut, the cabbage; das Lied, the song; das Faß, the barrel; das Dorf, the village; das Glied, the limb; der Wurm, the worm; das Gespenst', the ghost (spectre); das Volk, the people. (*e*) Decline the substantives das Roß, the horse (steed); das Los, the lot; das Hindernis, the hindrance (impediment, obstacle).

Continued

A KEY TO THE ABOVE EXERCISES APPEARS IN THE NEXT CHAPTER ON LANGUAGES

 Continued from page 1974

Imperative Mood. The imperative mood is formed by adding the terminations *e, emos, en* to the stem of all regular verbs of the first conjugation, and *a, amos, an* to the stem of those of the second and third conjugations. In the third persons, "let" is usually rendered by *que*. "Him," "her," "them," "us," are hardly ever translated, but the polite form is very seldom omitted. The numbers in brackets (1), (2), (3), indicate the conjugations.

IMPERATIVE MOOD

	Singular	*Plural*
(1)	*compr-e Vd*, buy	*compr-emos*, let us buy
	que compr-e, let him or her buy	*compr-en Vds*, buy
		que compr-en, let them buy
(2)	*beb-a Vd*, drink	*beb-amos*, let us drink
	que beb-a, let him or her drink	*beb-an Vds*, drink
		que beb-an, let them drink
(3)	*cumpl-a Vd*, fulfil	*cumpl-amos*, let us fulfil
	que cumpl-a, let him or her fulfil	*cumpl-an Vds*, fulfil
		que cumpl-an, let them fulfil

The familiar forms are: *compra, comprad; bebe, bebed; cumple, cumplid.* The negative imperative of the singular familiar form presents the remarkable anomaly of being different from the positive.—*no compres*, do not buy: *no bebas*, do not drink; *no cumplas*, do not fulfil.

IMPERATIVE of *Ser*, *Estar*, and *Tener*

Singular	*Plural*
Sea Vd, be	*seamos*, let us be
que sea	*sean Vds*
	que sean
esté Vd, be	*estemos*, let us be
que esté	*estén Vds*
	que estén
tenga Vd, have	*tengamos*, let us have
que tenga	*tengan Vds*
	que tengan

In positive sentences the object pronouns follow the imperative, but in negative phrases they are placed in front of the verb.—*comprémoslos*, let us buy them; *no lo beba Vd*, do not drink it. When the indirect pronoun *se* is affixed to the first person plural of the imperative the final *s* of the verb should be omitted.—*enviémoselo*, let us send it to her.

When the word "let" means "permit," it must be rendered by the imperative mood of the verb *dejar*.—*déjela Vd escribir*, let her write. In such sentences the second verb is frequently used in the corresponding person of the imperative.—*déjelos Vd que hablen*, let them speak.

"Please" is rendered by *haga Vd el favor de* (lit., Do me the favour of). The verb following the preposition *de* must be in the infinitive.—*haga Vd el favor de darme aquel sobre*, please give me that envelope.

EXERCISE XXV

to sing	*cantar*	to wait for	*esperar*
to ask	*preguntar*	to practise	*practicar*
debt	*deuda*	to forget	*olvidar*
ready	*listo*	to pardon	*perdonar*
cable	*cable*	to excuse	*dispensar*
word	*palabra*	good-bye	*adiós*
per month	*al mes*	by heart	*de memoria*
so fast	*tan de prisa*	confidence	*confianza*
to type	*escribir á máquina*	cab-rank	*parada de coches*
how much?	*¿ cuanto ?*	relation	*pariente*
free on board	*franco á bordo*	the nearest	*la más próxima*
dollar	*peso*	impatient	*impaciente*
sometimes	*algunos veces*	something else	*otra cosa*
for the present	*por ahora*		

1. Guardémosla. 2. Véndaselos Vd á ella. 3. Que lo escriban á máquina. 4. No se lo preste Vd. 5. Que lo aprenda de memoria. 6. No hablen Vds tan de prisa. 7. Déjelo Vd hablar. 8. No lo compre Vd en esa tienda. 9. Déjela Vd que cante. 10. Preguntemos. 11. Que no las firmen todavía. 12. Perdóneme Vd (or Vd perdone). 13. No los esperemos. 14. Esté Vd listo el (on) martes. 15. Tengamos confianza en el porvenir. 16. No lo olviden Vds.

Exceptional Imperatives. A number of verbs have irregular imperatives. The following should be remembered.

	Singular	Plural
to explain, *explicar*	*explique*	*expliquemos*
check, *comprobar*	*compruebe*	*comprobemos*
shut, *cerrar*	*cierre*	*cerremos*
think, *pensar*	*piense*	*pensemos*
try, *probar*	*pruebe*	*probemos*
look for, *buscar*	*busque*	*busquemos*
pay, *pagar*	*pague*	*paguemos*
begin, *comenzar*	*comience*	*comencemos*
bring, *traer*	*traigá*	*traigamos*
do, *hacer*	*haga*	*hagamos*
know, *saber*	*sepa*	*sepamos*
put, *poner*	*ponga*	*pongamos*
come back, *volver*	*vuelva*	*volvamos*
see, *ver*	*vea*	*veamos*
go, *ir*	*vaya*	*vayamos*
come, *venir*	*venga*	*vengamos*
repeat, *repetir*	*repita*	*repitamos*
tell, *decir*	*diga*	*digamos*
go out, *salir*	*salga*	*salgamos*
hear, *oir*	*oiga*	*oigamos*
order, *pedir*	*pida*	*pidamos*
choose, *elegir*	*elija*	*elijamos*
translate, *traducir*	*traduzca*	*traduzcamos*

EXERCISE XXVI

1. Bring it to me. 2. Let us sell them to her. 3. Excuse me, where is the nearest cab-rank? 4. Ask (it) a policeman. 5. Do not let us order them yet. 6. Why not? 7. Because we have something else to do for the present. 8. Please type those two letters. 9. Let him go out. 10. Do not come before seven o'clock. 11. Please put this glass on my table. 12. Let them pay their debts. 13. Choose one. 14. Tell me which is the cheapest. 15. Go at once and explain it to her. 16. Try to repeat it. 17. Let them translate the cable at once. 18. Let us look for it in the garden. 19. Do not be impatient.

Adverbs. Adverbs may be simple, derivative, or compound. Simple adverbs consist of a single word, as *antes*, before; *después*, afterwards. Derivative adverbs, which are formed in English by affixing the termination "ly" to the adjective, are formed in Spanish by adding *mente* to the feminine form of the radical adjective.—*rápido*, quick; *rápidamente*, quickly. When the adjective has only one termination for both genders, *mente* is affixed to this ending.—*hábil*, clever; *hábilmente*, cleverly. Compound adverbs are composed of two or more words. *á pesar de*, in spite of; *sin embargo*, however.

When several adverbs follow one another in the same sentence, *mente* is only added to the last.—*enérgica pero noblemente*, firmly but nobly.

Position of the Adverb. Although the position of the adverb in a sentence is to a certain extent quite optional, it generally follows the verb.—*vivía entonces en Londres*, he was then living in London.

When the negative words *ni*, neither, nor; *ninguno*, none; *nadie*, nobody; *ninguna parte*, nowhere; *nunca*, *jamás*, never; *nada*, nothing, follow the verb, the adverb of negation *no* must be placed in front of the latter. When those words precede the verb, *no* is not required.—*no le escribo nunca*, or *nunca le escribo*, I never write to him; *no viene nadie á ofrecernoslas ahora*, or *nadie viene á ofrecernoslas ahora*, nobody comes to offer them to us now.

Important Adverbs. The following important adverbs should be committed to memory:

down	*abajo*	then	*entonces*
perhaps	*acaso*	outside	*fuera*
besides	*además*	today	*hoy*
somewhat	*algo*	never	*jamás*
there	*allí*	far	*lejos*
scarcely, hardly	*apenas*	afterwards	*luego*
here	*aquí*	badly	*mal*
up	*arriba*	tomorrow	*mañana*
yesterday	*ayer*	less	*menos*
enough, rather	*bastante*	much	*mucho*
well	*bien*	very	*muy*
almost	*casi*	never	*nunca*
near	*cerca*	little	*poco*
how, as	*como*	perhaps	*quizás*
when	*cuando*	seldom	*raramente*
beneath	*debajo*	always	*siempre*
in front	*delante*	late	*tarde*
within	*dentro*	perhaps	*tal vez*
afterwards	*después*	so	*tan*
behind	*detrás*	early	*temprano*
above	*encima*	already	*ya*
opposite	*enfrente*	still, yet	*todavía*

EXERCISE XXVII

1. Please send us the goods free on board. 2. How much used you to pay? 3. Fifteen dollars per month. 4. When will he explain it to them? 5. He has already explained it to them. 6. Wait for me outside. 7. Does your partner know Spanish? 8. Very little, but he is studying it now. 9. Does he practise with you sometimes? 10. No; he never tries to speak with me. 11. I used to speak it rather well, but I have almost forgotten it. 12. Will you go to the theatre tonight? 13. I do not think so; they always arrive too late. 14. Please tell me how you pronounce that word. 15. With much pleasure. 16. Where shall I see you afterwards? 17. I will be here within (of) an hour; good-bye. 18. Do you know if the offices are up(stairs)? 19. No, sir; they are now down(stairs). 20. He has neither friends nor relations.

TRANSLATION OF READING EXERCISE [P. 1973]

The fine valley of Guadalquivir, which runs between two ridges of hills, is covered with orange woods and olive yards. Several clear streams traverse the plain, and fall into the river. Every brook had once its bridge. For two days we travelled up the river. The country it waters is very rich and beautiful; the plains are charmingly streaked with rows of olive-trees, towns and castles occur along the banks; the northern hills are covered with shadowy woods, and all the distant eminences of the south are green with corn plantations. At El Carpio is a Moorish mill with three huge wings which raise the water to a great height. The landscape near is very pleasing. At Andujar we took leave of the Roman road and of the river, of which, however, we had now and then a distant peep from the heights, and entered the Sierra Morena, the chain of mountains that divides Castille from Andalusia, rendered as famous by the wars of the Moors and the Christians as by Cervantes, who placed in it the scene of the most entertaining adventures of his hero.

KEY TO EXERCISE XXII

1. Entregará los recibos. 2. No cancelarán su cuenta hasta la próxima primavera. 3. ¿ Importará Vd todas las herramientas de los Estados Unidos? 4. No veremos al viajante este año. 5. Nuestros agentes embarcarán el ganado lo antes posible. 6. El Gobierno construirá nuevos puentes y carreteras. 7. La compañía de ferrocarriles emitirá mil acciones. 8. ¿ Estará Vd allí muy temprano? 9. La letra vencerá en Diciembre. 10. ¿ Quién traducirá esos documentos alemanes? 11. Tendré más tiempo el mes que viene. 12. Entonces habré aprendido el español.

KEY TO EXERCISE XXIII

1. No tenemos noticias de él. 2. ¿ Es esa carta para mí? 3. La tenía. 4. ¿ Por qué no los ha traido Vd? 5. No lo sabía. 6. ¿ Cuando nos enviará Vd la cuenta? 7. Los embarcaré enseguida. 8. El jefe está escribiéndole á él, no á ellos. 9. ¿ Lo construirá el Gobierno? 10. Las comprobaban cada dos días. 11. Deseamos verlo. 12. ¿ De donde los importa Vd? 13. Vd se lo daba á ella pero no á él. 14. ¿ Quién se lo ha prestado á Vd? 15. Su madre no la verá el mes que viene. 16. Estábamos hablándoles. 17. ¿ Era V. el que se los entregaba todos los días? 18. ¿ Guardarán las acciones ó las venderán? 19. Su amigo trabajaba conmigo. 20. Será más fácil traducirlo aquí. 21. El policía estaba explicándomelo, (*or* me lo estaba explicando).

Continued

Cutting Out the Material and Fixing on Shape. How Velvet Should be Handled. Making and Sewing in Head Linings.

HAT AND BONNET SHAPES

An espatra or buckram shape will need a non-transparent covering such as velvet, silk, or cloth, which is often put on plainly. In handling velvet, the way the shade runs is an important matter. In ordinary velvet, the material should be arranged so that the darker effect is seen when looking from the front of the hat to the back. In panne or miroir velvets, the material is often arranged the reverse way. In cloth the nap should run smooth from the front to the back.

Cutting Out the Material. Take the paper pattern that has been used for cutting out the shape.

Place all the pieces on the velvet with the shade running in the same direction, and each centre-front to the cross of the material [80]. Pin each part with lillikins, sticking them into the table to prevent marking the velvet. Cut out each part with ½ in. turnings. For the under brim place the velvet upper brim pile to pile on the velvet in the same position. Do not cut out the head of under brim, as it is best to fit it first.

Notice carefully in the case of brims that are much larger on one side than the other, as those of the Gainsborough type, that the pattern is placed correctly for cutting. Allow more than the ½ in. turning for under side, as the brim turns up so much. This also applies to boat shapes.

Mark the centre-front in all the pieces. If the brim has a join at back, the velvet will also have a join, neatly slipstitched. When a piece is put in for making a very fluted brim, this will also be necessary in the velvet covering. Backstitch the joins, open out, and flatten the turnings.

Putting On the Covering. We have now to learn how to fit the velvet to the brim.

Upper Brim. Place the upper brim on hat, and snick round headline till it fits. Be careful neither to cut too deeply—in which case the shape will show—nor insufficiently, thus preventing it lying flat round the headline. Pin in place with lillikins, smoothing away any creases very gently, but only along the straight threads. If stretched or smoothed out on the diagonal threads, it will not set flat.

Large shapes must be tacked as well as pinned, to keep the velvet well to the curves. Fine silk should be used for this, and a long stitch taken outside, and a tiny one underneath. Backstitch evenly round headline.

Draw the turning over the edge, but on no account pull it tightly, or the shape will contract. Pin all round. Catch stitch to the second wire on under brim [82], unless the under brim has been mulled all over, when the velvet is catch-stitched to the mull.

Cut away the turnings so that the velvet nearly meets the second wire to prevent any unnecessary fulness. Hold the brim with a small piece of velvet, pile downwards, in the left hand—the two piles facing each other prevents the brim from getting "plushed." Hold the brim very lightly, and prevent the edge getting plushed, or rubbed against the edge of a table or something similar.

Under Brim. For the under brim, place the velvet with the snick marking centre-front on the centre-front of shape. Fit and pin it in position as before. For large shapes tack once between headline and edge with fine silk. Cut off superfluous turnings to ½ in. With a fine needle turn in edge *exactly even* with the edge of brim. Pin with lillikins all round, about 1 in. apart. [81]

Slipstitch the two edges, with *strong* silk or cotton, taking alternately one stitch in the edge of the upper brim velvet and one in the turning of the under one. Sit in a good light, and be careful not to stretch the velvet of the under brim. Draw the silk fairly tightly. It is an operation requring great care, as this part of the hat shows more than any other.

Cut the headline with ½ in. turning, being careful not to snip beyond the actual headline, and stitch the turnings to headline of shape.

There is another method used in the best class of work, which gives a better edge, and is more satisfactory when an under brim of different colour or material is required.

Before covering the upper side of brim with velvet tack a piece of stiff French net, with the front on the cross, to the under brim. Tack it to the brim about half-way between headline and edge of shape. Cut it *exactly even* with edge, which must be wired with support wire, being careful not to contract the net. Mull the edge, and then cover the upper brim as explained.

Cover the under brim velvet, velvet-hemming the velvet to the net. The velvet must not be pulled tightly. Then slipstitch round edges of brim.

The point to remember in this method is to keep the net lining exactly the same size as the upper brim. In the process of wiring it is likely, unless very carefully handled, that the net contracts or stretches.

Sideband and Tip. Line the tip with sarcenet. If not done at this stage, it will have to be gummed in. Cover tip with velvet, allowing ¼ in. turning; pin all round, smoothing it over shape across the straight threads only. Use long backstitch with strong cotton, and secure it below the edge of the crown. Cut away closely any turnings and sew in head lining.

Fit the sideband carefully, and cut away unnecessary turnings. With a needle turn in bottom and top quite even with edge of crown, placing the join where the trimming is likely to cover it, always keeping centre-front to centre-front of shape and dark shade running up [81]. Backstitch one end of sideband, turn in the other

end, and slipstitch it down. A sideband of silk will require an interlining of muslin, and thick velvets are also better for interlining in the centre.

The inner edge of standing-up brims like toreador, turban, and similar shapes needs careful handling. Keep it smoothly to the shape, and see that the join is neatly done. Secure the top edge to the under brim edge by a catch-stitch. The outer edge is slipstitched last of all, keeping the edges even with the shape. The band of crossway velvet is joined, slipped over the edge, and turned in top and bottom with a needle.

Tam-o'-shanter and beefeater crowns are covered in one piece cut in a circle. The foundation is of net or leno, pleated to the sideband [74]. For covering, cut a larger round or a half-round, the other half left larger for standing up at left side. In soft material it should be interlined with fine leno. Gather or pleat the crown to top edge of sideband.

Lining the under brim of a felt or straw hat plainly with velvet or silk is done in exactly the same way as the under brim of a velvet hat, the velvet being slipstitched just above the wire round edge. If a velvet hat is to be lined with crossway folds of silk, tulle or chiffon, a lining of silk, leno, or soft net must be tacked to under brim to sew the folds to.

A broad edge 2½ in. to 3½ in. wide of velvet on an under brim is made by fitting the velvet to the under brim, slipstitching the edges and cutting out the centre-piece, allowing for a turning to the inner edge. This edge will not have any join.

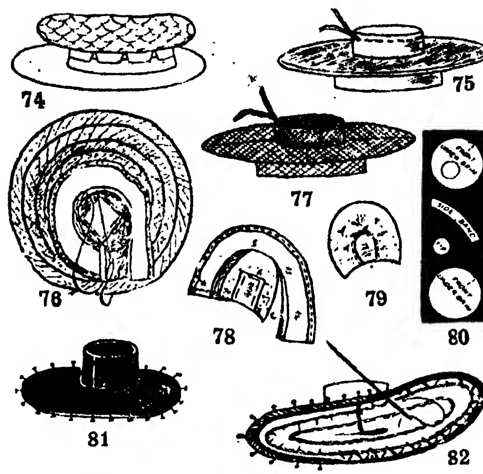
Bonnet shapes are cut out, shaded, and covered in the same way as hat shapes. Very few shapes are plainly covered. For covering shapes the velvet or cloth must be bought *on the straight*.

Head Linings. All hats, bonnets, and toques have their head linings sewn in *before* being trimmed. As weight must be avoided, sarcenet silk is used—it may be cut on the cross or straight. The former is the more economical, especially if a quantity is required; three head linings may be cut out of two crossway widths. Join the lengths first, hem, roll up, and use as required.

Measure the depth of crown, and add 2 in., of which ¾ in. is used for the hem, and ½ in. for turning at the headline When sewing in, allow 1 in. longer in length than the size of the head [76]. Make a hem ¼ in. wide of one cut edge, which should be run neatly [75]. It is called a hem though a running stitch is used, and must be kept quite straight and not stretched.

For the tip, cut a piece of sarcenet the size and shape of the tip. Sew in with a few very small stitches outside, large ones inside. For smooth felts, leghorns, velvet and cloth-covered hats, the sarcenet tip is gummed in, to prevent the stitches showing on the outside.

Sewing in the Head Lining. Use strong cotton (No. 36), start from the centre-back, turn in the cut edge ½ in., and ½ in. at the end. Take the stitch through the two thicknesses of sarcenet and through the sideband of hat. Sew in with the long back stitch, making the stitches not longer than ½ in., and keeping them just below the line of head. Work from right to left. Turn in ½ in. at end, and slipstitch the two



74-82. HOW SHAPES ARE COVERED

ends together. Smooth felt hats and toques have only half the thickness of the felt taken up when sewing in the head lining, unless the trimming will cover the small stitches; in that case, take them through, as it is stronger.

Run a narrow China ribbon from the centre-front in the hem, which will be drawn up *after* the hat is trimmed. It is left hanging to prevent the head lining being caught down in sewing on the trimmings.

Bonnets. In bonnets [78], the tip is cut to shape; in many cases, first sewn on tissue paper and sewn in the same way as for a hat, with this difference only, that across the back it is turned in once and slip-stitched on the velvet bind for neatness. Start the head lining at one ear, turning in 1 in., and work round to the opposite side. Insert China ribbon in hem, leaving also a turning; and, when the bonnet is trimmed, slipstitch the ends down the sides to meet at the back of the tip, securing ends of ribbon at the same time. Make a small slit in centre of hem, draw up ribbon, and tie in centre-front when bonnet is trimmed. Secure lining to the bonnet with a tie stitch in two places [79].

With smooth felt hats, toques, and bonnets with full or draped brims, the stitches are never taken right through, but only the top surface or inside of velvet is taken up. For very flat or peculiar shaped bonnets a piece of lining cut to shape is sewn in after the bonnet is trimmed.

Transparent head linings for lace, chiffon, tulle hats, or bonnets, are made of double chiffon, net and lisse. Cut lining twice the depth of sideband plus 2 in. for turnings [77]. Fold it in half and run ¼ in., from fold. Fold in half a sarcenet ribbon, the same colour as head lining, and ½ in. wide. Place this ribbon in turning of head lining at the cut edges. Sew in as for sarcenet head lining, taking the stitches through the centre of the ribbon and turning of chiffon. The stitches will be hidden when the ribbon is folded over. Run China ribbon in hem from centre-front [82].

ANTOINETTE MEELBOOM

The New Science of Metallography. Preparing Specimens. Alloys and their Preparation. Characteristics and Composition of Alloys.

METALS UNDER THE MICROSCOPE

Metallography. The branch of metallurgical science termed *metallography* is, in the broadest sense of the word, the description of the structure of metals and alloys. It is not necessarily limited to the employment of the microscope or even to the hand glass, for the fractured surface of a metal often reveals valuable information when viewed with the naked eye. We form an opinion of the nature of metals also from their colour, their manner of solidifying in a mould, and the texture of their surfaces. But only very limited information as to the structure of metals can be obtained by simply using the unaided eye to examine the rough or unpolished surface. The structure of what may be termed the *internal architecture* of metals can be accurately ascertained only by the use of the microscope, generally on the polished and etched surface.

Microscopic Investigation. One of the great results of the microscopic investigation of metals has been the confirmation of their crystalline character, even in metals in which such a structure could not have been anticipated or proved by other means. The appearance of the polished structure of a metal under the microscope seldom reveals definite and well-formed crystals—in fact, the conditions of solidification from the molten state and the mechanical treatment to which most metals are subjected militate against the formation and retention of the true external crystalline form. The result is a compact mass of irregular-shaped bodies termed *crystal grains*, giving the surface the appearance of a mosaic with irregularly shaped stones.

Character of Crystal Grains. In the act of solidifying, crystals begin to form and gradually grow in size according to the time allowed for their development. The junction lines are the surfaces of the crystals, and appear as thin dark lines in the micro-structure. If impurities be present, the crystals of the pure metals in the act of crystallising reject such impurities, which collect at the crystal boundaries. The particles of the pure metal coalesce together so as to form little islands surrounded by the impurity, which thus forms the investing membrane, separating the crystals from each other.

Obviously, the mechanical and physical properties of an alloy will depend largely on the nature of the investing membrane, since the crystals themselves may be quite malleable and ductile, while the mass of the metal, with the including impurities, may be quite brittle. The main factor in the development of crystalline structure is the temperature. It is a well-recognised fact that the more slowly a metal is cooled from the freezing point, the larger will be the dimensions of the crystals, the more perfectly will they be formed, and the more symmetrically will they arrange themselves with regard to each other. On the other hand, if a metal be submitted to pressure, not only will the individual crystals be distorted, but the orderly arrangement of the whole mass will be disturbed. Messrs. Ewing and Rosenhaim have shown that when a piece of metal is strained in tension its crystal grains become elongated in the direction of the tension; but when the metal has been annealed all signs of the elongation disappear from the crystalline pattern revealed by the microscope, and the metal has assumed its original condition. On investigating the metal under strain, when the metal is stretched beyond its elastic limit it has also been found that sharp and fine black lines appear on the surface of the crystals, parallel to each other in each crystal but in different directions in different crystals. These lines are not cracks, but *slips* along the cleavage or guiding planes, and are termed *slip-bands*. Such bands are also produced by compression or tension, and it is in virtue of this action that plasticity in metals is possible.

Preparing Metals for the Microscope. For exact examination of the structure of metals it is absolutely necessary to have the surface polished free from scratches, as well as perfectly flat, if high powers are to be used, since scratches and other imperfections tend to mask the real structure and convey an erroneous impression regarding the character of the components. Polishing is an art requiring skill and patience, and while no exact rules can be given to cover all cases, the following will serve as a general guide. The section of metal should be about ½ in. square, and ⅛ in. thick. It may be mounted for final examination on a glass slide with Canada balsam, plasticine, wax, or other suitable adhesive materials, or soldered on to a flat piece of metal. The first process is to rub it smooth on a dead-smooth file, and afterwards to remove the scratches with emery and rouge. Different grades of emery can be purchased, marked O, OO, OOO, and OOOO, respectively. Each grade should be mounted on a smooth block, and the specimen rubbed on each in turn, care being taken to rub at right angles to the former rubbing, so as to obliterate the previous marks completely. The final polishing may be done on a skin of chamois leather coated with the very finest rouge.

Etching the Specimens. Various etching liquids are used, varying with different metals. Those employed for steel are dilute nitric acid, tincture of iodine, infusion of liquorice, ammonium nitrate and picric acid; for copper and brass, dilute nitric acid, hydrochloric acid and

ammonia; while for alloys with much zinc, potash is the best reagent. In fact, numerous etching liquids are available.

It is sometimes an advantage to polish in bas-relief. When a complex body is polished, its different constituents tend to wear away unequally, and it is possible, by placing it in convenient positions, to show the structure by the unequal relief. To do this, the section is polished on a bed elastic enough to bring out the finest details, such as parchment on soft wood, and moistened with wet rouge. Another method of polishing is known as *polish attack*. This consists of adding to the polishing pad some liquid which exerts a slight chemical action when assisted by the friction of the rubbing.

Heat Tinting. Etching polished metals with corrosive liquids is more or less liable to lead to the confusing of the constituents and crystalline structure. With feeble etching the component parts are, as a rule, revealed; with strong etching the granular, and often the crystalline structures, are developed. By heating polished sections at different temperatures the constituents become differently coloured by oxidation films, and may therefore be detected. This has the advantage over etching, that none of the metal is dissolved, and the surface remains flat.

The Microscope. A very simple form of microscope is all that is necessary for examining metals, but the lenses must be of good quality. The objectives must give a flat field, should be achromatic, and should possess clear definition. A bull's-eye condensor is required for condensing the light on to the object, or on to the vertical illuminator.

The most useful objectives are 1 in. and ¼ in., which give magnifications from 50 to 200 diameters. Two kinds of illuminators are in use, termed respectively *oblique* and *vertical* illuminators. In the former, the microscope is generally tilted at an angle, and the light thrown directly on the object, which reflects it to the eye. For vertical illumination a piece of glass is arranged at an angle of 45 degrees, so as to reflect a horizontal beam of light on the object, which then reflects the light vertically up the tube of the microscope to the eye. Instead of the plane glass reflector, a right-angled prism may be used. It is fixed in a brass mounting, and may be placed just above the objective, or just under the eye-piece.

Iron and Steel. *Wrought iron* is composed of three chief parts: the crystals of iron, termed *ferrite*, the carbide of iron, termed *cementite*, and the included slag which imparts to iron its fibrous structure. *Cast iron* is of two chief kinds—namely, grey cast iron, consisting chiefly of ferrite and graphite; and white cast iron, containing no free ferrite, but iron combined with carbon in a form which imparts to it a white crystalline structure and great hardness. *Steel* is composed of different components, according to the amount of carbon present. When the steel contains less than 0·9 per cent. of carbon, it consists of ferrite embedded in a matrix of what is termed *pearlite*, which is an intimate mixture of ferrite and cementite in alternate laminæ. When the steel contains just 0·9 per cent. of carbon, the whole mass is composed of pearlite, with no free crystals of ferrite. This is termed the *eutectic mixture*, and the iron is said to be saturated with carbon. When the steel contains over 0·9 per cent. of carbon, it consists of crystals or grains of pearlite, surrounded by a network of cementite, which hardens the steel according to the quantity present.

A section of pure iron, when polished and etched in dilute nitric acid, is seen to consist of irregular-shaped grains or crystals. Two distinct types are generally observed: (1) smooth and bright areas consisting of pure iron (ferrite); and (2) greyish rough areas of a wavy or mottled appearance, being more readily attacked by nitric acid. When carbon is present the crystals of ferrite are surrounded by a matrix of pearlite, which encroaches more and more on the ferrite as the carbon is increased, as shown in the plates facing pages 2118 and 2119 [**1** and **2**]. The pearlite matrix is seen in the latter to have a characteristic banded structure. When the steel contains about 0·9 per cent. of carbon, the whole mass consists of pearlite. When the carbon is increased beyond 0·9 per cent., the ferrite crystals have entirely disappeared and have been replaced by pearlite; the excess of carbon over 0·9 per cent. then appears in combination with iron as free cementite, as seen in **3**. These three figures represent the steel in the normal state.

Effects of Annealing Steel. On annealing steel a change is produced in the physical properties, and this change is coincident with a change in structure. By *annealing* is meant heating to a certain elevated temperature and cooling slowly to the ordinary temperature. The effect on the micro-structure by annealing is seen in **4** and **5**. The changes which have been produced occurred mainly in the ferrite, but the pearlite has become more granular. The effect of annealing high carbon steel at 620° C., as seen in **6**, is chiefly to sharpen the outline of the cementite. The above remarks apply also to **7, 8** and **9**, but the effects are intensified by the long soaking or annealing for 12 hours, the cementite and pearlite being very well defined in **9**. In all the specimens which have been described the white parts represent ferrite and cementite respectively, and the darker parts the pearlite.

Malleable Iron. Malleable iron castings consist of white cast iron which has been subsequently annealed in iron boxes packed with hæmatite. The carbon in the castings before annealing is chiefly in the combined form, as cementite, and this undergoes a more or less complete change in the process of annealing. Some of the carbon is removed, but the greater part remains as graphite. On the outside of the casting the carbon is oxidised by the oxygen of the hæmatite, leaving ferrite. On the other hand, there is a store of carbon towards the centre of the bar in the form of amorphous graphite, which is continually re-

carburising the ferrite by solid diffusion. The structure of the outside, intermediate, and centre of the casting is seen in **10**, **11**, and **12**.

Copper. The micro-structure of copper varies from the mode in which it has been produced. Electrolytic copper is confusedly crystalline. Pure copper consists of irregular-shaped crystal grains with very fine and sharp boundaries. These crystal grains increase in size according to the slowness of cooling. Small secondary grains are often built up from the larger ones. Fig. **13** is the top of a button of copper. When copper is rolled or hammered, as in **14**, the secondary grains are elongated in the direction of the rolling, and finally may become so attenuated as to break down. Annealing reduces the strain and allows the grains to rearrange themselves. Fig. **15** is copper foil, etched in nitric acid, and shows fine elongated grains.

Tin. When an ingot of pure tin is cast it shows a bright surface; but if impure, the surface shows a structure of dendritic crystals. If the surface of the ingots be etched, they are seen to be coarsely granular. Fig. **16** is from the base of a very thin sheet of tin cast on stone. Fig. **17** shows a piece of hammered tin, by oblique illumination, etched with dilute nitric acid. The original structure has disappeared, and a finer crystallisation has taken its place. Annealing causes a growth of the crystals. Fig. **18** shows the structure of tin after annealing.

Zinc. An ingot of zinc shows dendrites similar to those of lead and tin. Fig. **19** shows part of a dendrite on the surface of metal cast on stone. There are three main axes.

Aluminium. On the sides and base of a bar of aluminium, where it has cooled in contact with the mould, dendrites of a leaf-like form are seen, and in **20** are several of these dendrites which are the centres of crystallisation.

Lead. Cast lead exhibits a dendritic structure, and the dendrites are the skeletons of grains or primary crystals. In **21** the secondary crystals are seen. This surface was the last to solidify in an ingot cast in stone. Etching brings out the primary crystallisation very distinctly.

Platinum. Fig. **22** shows dendrites on the surface of a platinum button. They consist of two axes at right angles, and form skeletons of the crystals, as in case of the metals mentioned above.

Silver. Fig. **23** shows the surface structure of an ingot of silver. Three or more primary crystals are seen to be built up of numerous secondaries, possessing distinct orientation.

Gold. Pure gold crystallises in hexagonal crystals, which are built up of secondary crystals. Fig. **24** shows some of the dendrites met with in a slowly cooled gold button. Rolling breaks down the primary crystals, producing a finer structure.

The Modern Science of Microscopic Metallurgy. Though the microscopic observation of metals is a development of recent growth, it has been one of the most fruitful in results, and has great promise for the future. Observers see what actually takes place in the ultimate structure of metals and alloys. A piece of iron, steel, copper, or tin or gold is not the simple body which it was once thought to be. Though it is an inorganic substance, an element so called, its structure is very complex, and it varies so much with differing physical conditions, as temperature, stress, strain, and so on, that the aspects revealed by the microscope under the action of reagents are almost suggestive of new and organic bodies. Even in those preparations of metals which are chemically pure, the anatomical changes which occur under changes in physical states are remarkable. And when impurities are present they reveal startling differences, which are complicated by the alterations which the impurities themselves undergo, and by reason of the way in which they interact on each other.

If any commercial iron or steel whatever is taken, it never contains less than half a dozen elements, besides the pure iron itself—carbon, silicon, phosphorus, sulphur, manganese, sometimes traces of arsenic, titanium, and in many of the steels, in addition, nickel, chromium, vanadium, molybdenum, tungsten. Some are allotropic, occurring in different guises, carbon being the most chameleon-like. Each element is striving to realise its own molecular destiny, but each has affinities or repulsions towards the others. And thus every kind of metal, however pure it may appear commercially, is really and truly an alloy, a mass alive with chemical reactions. The study of metallography is therefore not now a dilettantic pursuit, but is one eminently practical, a volume wherein the behaviour of metals in all their aspects of physical change can be read as in an open book, and the lessons gathered applied to manufacturing purposes.

Microscope *versus* Rule of Thumb. The effects of temperature are rendered visible in many ways in all metals and alloys. The constituents take on new or more pronounced aspects and formations, and from these the causes of physical phenomena in working become, if not always satisfactorily elucidated, at least traced in their relation to certain practical results. This is the case in the hardening and annealing of steel. It helps to explain the fact that the temperature for hardening, to be properly done, must not vary more than a few degrees, 5° or 10° on either side of a "critical" temperature for a brand of steel of a given chemical composition. Incidentally the knowledge of this one fact has had the result in the best present-day practice of removing the work of hardening and tempering from the forge, and the somewhat loose colour test of the workman's eye, to that of the closed furnace, the temperature of which is measured exactly by means of a pyrometer inserted in the furnace.

Another aspect revealed by the microscope is the effect of annealing on specimens which indicate faulty structure. The same steel re-heated to various temperatures has such greatly different aspects that they might well be taken for different metals. The heat treatment of metals, as it is termed, has been vastly advanced by the aid of the microscope. It explains much that has long been known by experience, though not understood, and it provides definite and exact knowledge for that which was previously of a vague and hazy character.

The Insufficiency of Chemical Analysis. The minute cracks in steel which result from quenching at too high a temperature are readily seen. Again, the presence and extent of foreign matters are clearly visible in polished specimens. The slag and cinder and dirt which occur in steel and in wrought iron show very clearly the fissures and gaps which cause actual separation of the metal itself. When such specimens are bent, fracture ensues along the lines where the slag or dirt occur.

One fact which stands out conspicuously in connection with the microscopic examination of metals is that chemical analysis alone does not tell the whole story of the behaviour of metals and alloys. The microscope has demonstrated most conclusively that variations in temperature and treatment in cooling will produce vastly different results in metals and alloys having precisely the same chemical constitutions.

Profits of Departments and Branches. Branch Books. Manufacturers' Cost Sheets. Stores. Plant. Establishment Expenses. Contractors' Accounts.

BRANCH AND COST ACCOUNTS

Many wholesale and retail trading concerns have distinct departments, each working independently of the others. Where this is the case it is necessary for the proprietors to know, not only the result of the trading as a whole, but also the results of the operations of the separate departments. The reason for this is that while a general profit and loss account might show that the whole business was being carried on at a profit, it would not disclose what might be the fact—*viz.*, that this was owing to one or two departments earning good profits, while others were being carried on at a loss.

Departmental Accounts. A system of accounts has, therefore, to be formulated which will show, not only the general result, but also the profit or loss on each department. To achieve this, a separate trading account for each department must be prepared, and the best method of doing this is so to arrange the books of original entry that the information required for the purpose is readily available. In a business such as is now being considered, it is usually sufficient for the object in view to ascertain only the gross profit on each department, leaving general establishment expenses to be debited to a general profit and loss account. If it is desired to arrive at the actual net profit of each, a simple method is to charge the departments with a percentage of the general expenses, such as rent, rates, lighting, counting-house salaries, etc., such percentage being based either upon the amount of wages paid or the amount of turnover.

The case of a business will be taken having four departments—*viz.*, mantles, dress materials, felts, and trimmings. The first step is so to arrange the purchases book that it shows the amount of goods bought for each department as well as the total. This object can be attained by having separate purchases books for each department, but it is generally found more convenient to have one book only, ruled in the following form, with such modifications as may be required by the particular business for which it is used:

Date.	Invoice No.	Name.	Bt. Led. Folio.	Total of Invoice.	Mantles.	Dress Materials.	Felts.	Trimmings.

The amount of the invoices will be posted to the credit of the sellers' accounts in the bought ledger in the ordinary way, while the totals of the columns relating to the four departments will be respectively posted to the debit of an account opened in the general ledger for each department. The salaries and wages book will be ruled in such a manner as to show the amount paid to the employees in each department separately, or else the book must be dissected monthly. Whichever course is adopted the amount attributable to each department must be posted to the debit of the respective departmental accounts.

Departmental Sales. With regard to sales, separate books will be required for cash and credit sales, and the methods of keeping them necessarily differ. The cash sales will be made over the counter, and salesmen will be allocated to the various departments. Each salesman will have his own book, in which he will make out a bill for each transaction, which may, in some instances, include goods from all the departments. The books will contain the bill forms in duplicate, in order that carbon copies may be taken. The original bill is receipted and handed to the customer, and the duplicate is sent to the cashier. At the end of the day each salesman's cash must agree with the total of his duplicate bills in the possession of the cashier. In many firms the money received from the customer is handed at once to the cashier, with the original and duplicate bills. He receipts the former, which is handed to the customer, while the latter is retained with the cash. The salesman's duplicates are entered by the cashier in the cash sales book, which is ruled with columns for each department and for the total.

If the number of transactions justifies it, a separate page will be set apart for each salesman. The columns will be totalled daily, and the cashier must agree his total cash received with the total of the sales during the day. At the end of the month the daily totals of the departmental columns are extracted, and their aggregates posted to the credit of the departmental accounts in the general ledger.

The credit sales will be dealt with in the same manner as in a business where there are no departmental accounts, except that the sales books will be ruled with columns for the various departments in the same way as in the case of the purchases book. The totals of the columns will be posted monthly to the credit of the

departmental accounts in the general ledger, while the separate items are posted daily to the debit of customers in the sold ledger.

Departmental Trading Accounts. The results of the posting of the original books in this manner will be that separate trading accounts for the various departments will exist in the books, while the trading account of the business as a whole can be made out in the form shown here.

The preparation of the trading account in this form enables the proprietor to see at a glance, not only the gross profit of the whole business, but also that of the separate departments. The result is that a failure by any department to earn the rate of profit which may reasonably be expected is disclosed. In the case with which we are dealing it is apparent that there is something wrong with the felts department. The mischief is in either the stock, purchases, or sales. Stock may have been taken too high at the end of the last trading period, or too low now. If it is neither of these things, then the department may have been buying too dear, or selling too cheap. The system of accounts has done its duty and disclosed the existence of the defect. It is for the proprietor to discover the cause and the remedy.

Branch Accounts. The reason which renders the keeping of departmental accounts desirable applies with even greater force to branch accounts. It scarcely needs stating that the proprietor of a business with several branches requires to know the result of the trading at each of them. The methods of keeping the accounts of branches differ according to the requirements of the business; but there are general principles which can be observed in every case. Let us assume that a branch has been opened and a manager installed. A quantity of goods, and a supply of cash for petty expenses, are sent by the head office to the branch, where a set of books will be kept in which entries will be made recording those facts. The goods and cash accounts in the branch ledger will be debited with the value received, and an account opened for the head office will be credited. All goods and cash received from the head office during the year will be similarly treated; while, if the manager is authorised to purchase goods himself for the branch, he will debit goods account with the amount purchased and credit the sellers.

TRADING ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1905

Dr.	Mantles.	Dress Materials.	Felts.	Trimmings.	Total.
To Stock, Jan. 1st	1,280 0 0	784 0 0	358 0 0	425 0 0	2,847 0 0
„ Purchases	4,800 0 0	2,000 0 0	1,087 0 0	2,478 0 0	10,365 0 0
„ Wages	500 0 0	200 0 0	160 0 0	240 0 0	1,100 0 0
„ Gross Profit	2,040 0 0	937 0 0	18 0 0	947 0 0	3,942 0 0
	8,620 0 0	3,921 0 0	1,623 0 0	4,090 0 0	18,254 0 0

Cr.	Mantles.	Dress Materials.	Felts.	Trimmings.	Total.
By Sales, Cash	2,500 0 0	1,700 0 0	993 0 0	1,500 0 0	6,693 0 0
„ do. Credit	5,000 0 0	1,500 0 0	200 0 0	2,000 0 0	8,700 0 0
„ Stock, Dec. 31	1,120 0 0	721 0 0	430 0 0	590 0 0	2,861 0 0
	8,620 0 0	3,921 0 0	1,623 0 0	4,090 0 0	18,254 0 0

Branch and Head Office Returns. All the cash received for sales must be banked daily, and weekly returns of all business done sent to the head office every Monday morning. If sales are allowed on credit, details must be furnished to the head office, as it is usual for accounts to be rendered from there. If cash is received by the head office from branch debtors, the branch must be notified in order that the amounts received may be credited to the customers, the head office, of course, being debited with the amounts as the receipt of them is notified. Payments to creditors for goods supplied to the branch direct will probably be rare, and will, as a rule, be made by the head office. This will render necessary entries in the branch ledger, debiting the creditors with the amounts they receive, and crediting head office account with the amount paid for the branch. The result will be that the head office is credited with all goods and cash supplied to the branch, and with payments made on its behalf, while it is debited with all cash paid into the bank, and with all amounts it receives from debtors for goods supplied by the branch.

Head Office Entries. In the head office books the entries will be the reverse of those in the branch ledger. All goods and cash supplied will be debited to an account opened in the name of the branch, the cash and goods accounts, of course, being credited. Any goods returned by the branch will be debited to goods and credited to the branch. Payments made for the branch will be debited to the branch office account and credited to cash, while amounts received by the head office for the branch will be debited to cash and credited to the branch account.

At the end of the trading year a trial balance of the branch ledger will be prepared by the manager. It will contain in the debit column the balances of wages, purchases, discounts, cash and any expenses accounts, as well as the customers' balances; while on the credit side will appear sales and creditors' balances. The balance of the head office account will also appear in one of the columns. This trial balance will be sent to the head office, and, if the balance of the head office account shown therein agrees

Dr.	HEAD OFFICE ACCOUNT IN BRANCH OFFICE LEDGER	£	s.	d.			£	s.	d. Cr.
1905. Jan. to Dec.	To Cash paid in by Branch	1,460	0	0	1905. Jan. 1	By Goods supplied	200	0	0
	,, do. received from Branch debtors	580	0	0		,, Cash for expenses ..	25	0	0
					Jan. to Dec.	,, Goods supplied ..	1,100	0	0
Dec. 31	,, Debtors on books 200 0 0					,, Cash for petty expenses	250	0	0
	,, Stock on hand 180 0 0					,, do. for rent, rates, etc. of Branch	200	0	0
	,, Cash do. 10 0 0					,, do. paid to creditor of Branch	30	0	0
		390	0	0	Dec. 31	,, Profit as per trading account	625	0	0
		£ 2,430	0	0			£ 2,430	0	0
					1906. Jan. 1	By balance, b/d ..	390	0	0

Dr.	BRANCH OFFICE ACCOUNT IN HEAD OFFICE LEDGER	£	s.	d.			£	s.	d. Cr.
1905. Jan. 1 to Dec. 31	To Goods supplied.. ..	1,300	0	0	1905. Jan. to Dec.	By Cash paid in by Branch	1,460	0	0
	,, Cash for expenses ..	275	0	0		,, do. received from Branch debtors ..	580	0	0
	,, do. paid to creditors for rent, etc... ..	230	0	0	Dec. 31	,, Floating assets on hand	390	0	0
Dec. 31	,, Profit as per Branch trading a/c	625	0	0					
		£ 2,430	0	0			£ 2,430	0	0
1906. Jan. 1	To balance, b/d	390	0	0					

with the balance of the branch account as appearing in the head office ledger, a trading account of the branch will be prepared and the balance thereof transferred to the head office account in the branch ledger. If the result is a profit, it will be entered on the credit side of the account ; if a loss, on the debit side.

The reason for the agreement of the two accounts in the respective books should be apparent, but in order to make the matter quite clear the summarised accounts are given at the head of this page.

If there are any fixed assets of the branch, such as lease, fixtures, furniture, etc., they are not included in the branch ledger, but are debited to their respective accounts in the head office ledger. When the balance-sheet of the business as a whole is prepared, they are included therein with other assets of a like nature. The floating assets of the branch, consisting of debtors' stock and cash, are also incorporated with similar assets belonging to the head office and to other branches, and are brought into the general balance-sheet instead of being shown as a debit balance owing by the branch to the head office.

Cost Accounts. It is necessary in all businesses having for their object the manufacture or production of commodities that there shall be an efficient system of accounts enabling the proprietor to arrive at the cost of the article produced. The main cause from which this necessity arises is that the manufacturer must know the cost of what he produces in order that he may fix a price at which to sell, or to give an estimate for a contract for similar work in future. There are two principal classes of undertaking in which a system of cost accounts is of the utmost importance—*viz.*, (1) those engaged in the production of a particular article, *e.g.*, collieries, ironworks, brickworks, etc. ; (2) those in which the business consists of the carrying out of a definite piece of work, known as a contract, where knowledge of the actual cost of each contract is required.

For both classes of undertaking the general principles to be observed are the same, and consist of the careful subdivision of the various heads over which the cost of performing the work is spread. In both kinds of business the cost of the finished article or of the contract is made up of (1) materials, (2) labour, (3) general expenses necessarily incurred in carrying on the business, including wear and tear of machinery and plant in producing the article or executing the contract. The records to be kept in order to obtain the desired result necessarily vary in different businesses. In a manufacturing concern, where one class of article is produced, the cost account is in the nature of the debit side of a trading account for a limited period, frequently a week or a month ; while in the case of a contractor a separate cost account is kept for each contract undertaken. In the former class, however, the items are more highly classified than in the trading account of an ordinary business.

Manufacturing Cost. The wages paid are analysed over the different classes of workmen or according to the various stages of the work, and the cost of supervision directly attributable to the performance of the work is also included. The materials and stores used are charged at cost, and a charge is also

made for what may be termed Indirect Expenses, or, as they are usually called, Establishment Expenses. These consist of the depreciation naturally arising from the continual using of the machinery and plant in the production of the article. and also of the cost of upkeep of the business apart from the direct cost of manufacture or production. They include rent, rates and taxes of the factory and workshop, the salaries of the factory managers, and the cost of motive power. Many businesses draw a line here, while others add general office expenses, discounts, bad debts, commissions, etc., before arriving at a figure which is deemed to be the cost.

In this class of business this periodical summary is generally called a *cost sheet*, and gives a comparison between the current month and the preceding one. In the case of collieries, brickworks, etc., a statement is added showing the cost per unit during the month. In a colliery the unit is the ton, in a brickworks, 1,000 bricks. Cost accounts or sheets on somewhat similar lines, but of a more elaborate nature, are also prepared in the case of tramway, gas, water, electric light and railway companies for the purpose of ascertaining the cost per unit.

For the purpose of making the figures required for the final cost account or summary easily obtainable, the subsidiary books must be suitably ruled. The wages book is kept in tabular form, and shows not only the amounts paid weekly for the different classes of labour, but also the amount which is attributable to each contract or department. Care must be taken to ensure that the amounts charged in the various cost sheets or contract accounts agree in total with the amount actually paid. It will sometimes be found that the whole of the wages paid cannot be allocated over the various processes or jobs. In such a case the balance of wages must be regarded as part of the general establishment expenses.

Stores. The detail which, as a rule, gives more trouble than any other in connection with cost accounts is that of stores—*i.e.*, materials used in the process of manufacture of which a certain stock is kept on hand. The cause of the trouble is the difficulty in agreeing the amount of stores on hand at any time with the amount that should be there, having regard to the purchases and the amount used according to the costs sheets. The deficiency is to some extent caused by waste, for it is impossible to take most kinds of stores into stock in bulk, and hand it out in small quantities without some shrinkage. But the chief danger is from leakage by pilfering, and to guard against it several devices have been adopted. One in very general use is that stores are only handed out by the storekeeper upon written requisitions signed by properly authorised persons. The requisitions state the purpose or contract for which the stores are required, and after the demand has been complied with they are sent by the storekeeper to the counting house, where the stores are charged out in accordance with the particulars given on the requisition.

The best way of ensuring that this is accurately done is to have a summary of the stores issued during a given period prepared in columnar form. The columns are headed with the name or number of the department, or contract, for which the stores are required, and at the end of the week or month the total of each column is posted to the debit of the cost account indicated. The stores are priced out at cost, and this step should be carefully checked, as improper pricing might open the door to considerable fraud. For this reason the pricing is better left to the counting-house staff than to anybody handling the stores.

Stores Accounts. In some establishments stores accounts of a more or less elaborate design are kept, showing both quantities and prices of stores received and issued. Where these are accurately kept—and there is no reason why, with care, they should not be—they are of considerable value in operating as a check upon the stores in hand. Even when the accounts under this system are properly kept, there will be differences, but they should be small in amount. If any great discrepancy were discovered between the stores appearing by the accounts to be in hand, and those actually in stock, as ascertained by stocktaking, searching inquiries would be made to ascertain the cause.

Any stores not required for the purpose for which they were issued are returned into stock, with a note of their quantity and the job from which they are returned. Separate accounts will, of course, be required for the various kinds of stores, and as it will be of assistance to the student in the proper understanding of the subject, a specimen ruling for an account is given in the table below.

SLATES ACCOUNT

RECEIVED								ISSUED							
Date.	No. of Invoice or Return Note.	From whom obtained.	Quantity.			Price per 1,000.	Amount.	Date.	No. of Requisition.	Contract or Department.	Quantity.			Price per 1,000.	Amount.
			12 by 6	16 by 8	20 by 9						12 by 6	16 by 8	20 by 9		
1906. Jan. 1		Brought forward	5,000			40/-	10 0 0	Jan. 8	513	No. 35 ..	3,000			40/-	6 0 0
		do. ..		4,000		50/-	10 0 0	,, 15	516	,, 27 ..			4,000	75/-	15 0 0
		do. ..			6,000	75/-	22 10 0								
,, 15	68	A. B. & Co.	15,000			40/-	30 0 0								
,, 15	68	do. ..			10,000	75/-	37 10 0								
,, 30	15	Cont. 18 returns..		650		50/-	1 12 6								

Most large contracts require that special materials shall be purchased for them. These materials do not pass through the stores accounts, but are charged to the contract accounts direct from the purchases book.

Plant. In the case of a contractor, the plant used on the works in progress will be dealt with in a similar manner to the stores, so far as charging it out to contracts or departments is concerned; but it is not so usual to keep plant accounts as store accounts. A good method of recording the movements of plant is that mentioned above in connection with stores, by which it is only issued against proper requisitions, which are summarised periodically, and the totals charged out to the different jobs where the plant is being employed. In regard to plant, a point arises which also affects stores to a limited extent. When plant has been in use for perhaps several months on a contract, where it has been exposed to the weather, it naturally deteriorates in value, and is not worth as much when returned as it was when issued. The depreciation in value is made to fall against the contract by the plant being credited to the contract account at a lower rate than that at which it was originally charged. It thus goes back into stock at its diminished value.

Contract Accounts. It is convenient to keep the accounts of contracts in tabular form, in order that the expenditure under the various heads may easily be ascertained at any time. The headings will vary according to the nature of the business, and that given on this page is a useful form in the case of a builder.

When the contract is completed, the account is closed, as shown, by crediting the amount due from the person for whom the work has been carried out, and also the then value of any plant and stores returned. The difference between the two sides of the account is obviously the profit or loss upon the contract. The debit to the owner of the work is shown on an account in a ledger known as the contract ledger.

This ledger, being used for keeping the accounts of persons for whom work is being done, and who are, therefore, indebted to the business, it would naturally be supposed that the balances therein were debit balances. It usually happens, however, that payments on account of the work are made by the owners during the progress of the contract. When this is the case, the amounts received are debited to cash and credited to the payer in ordinary course. As the owners of the various works are not debited with the contract price until the completion of the contracts, it follows that their accounts in the meantime show credit balances, against which have to be set the several debits on the contracts accounts.

Establishment Expenses. The nature of establishment expenses has been explained, but nothing has yet been said upon the manner of apportioning them between the various jobs in the case of a contractor, or between the various departments or processes in a manufacturing concern. The practice upon this point differs, and it depends to some extent upon the nature of both the business and the particular expense. It will be sufficient for the present purpose to indicate the various systems, as no rule can be laid down for general application. There are three principal methods of charging the department or contract—*viz.*: (1) such a proportion of the total establishment expenses as the cost of the contract bears to the cost of all the firm's work; (2) a similar proportion based on the time charged; and (3) a proportion calculated in the same way upon the basis of wages paid. The object is that each department or work should be called upon to bear its fair share of the general expenses of the upkeep of the establishment, and that method is adopted which is best calculated to bring about this result.

J. F. G. PRICE

Dr. WAREHOUSE AT NEW STREET, E.C., FOR MESSRS. JONES & CO. CONTRACT No. 82 Cr.

Date.	Particulars.	Folio.	Materials. Special.	Materials. From Stores.	Wages.	Plant.	Establishment Expenses.	Total.	Date.	Particulars.	Folio.	Contract Price.	Stores and Plant Returned.	Total.
Jan. 1	To forward . .		2,500 0 0	850 0 0	1,750 0 0	230 0 0	180 0 0	5,510 0 0	Jan. 31	By Jones & Co., Contract completed . .	C.L. 21	6,000 0 0		6,000 0 0
„ 6	„ wages for week . .	WB 80			20 0 0			20 0 0		„ Scaffolding, etc.	S.L.		150 0 0	150 0 0
„ 31	„ net profit	P.L. 101						620 0 0						
			2,500 0 0	850 0 0	1,770 0 0	230 0 0	180 0 0	6,150 0 0				6,000 0 0	150 0 0	6,150 0 0

Terms and Operations. Definitions. Simple Substitutions. Positive and Negative Quantities. Addition and Subtraction.

ALGEBRA

DEFINITIONS

1. Algebra, like Arithmetic, deals with the properties of numbers. Algebra, however, has much greater scope than Arithmetic; for, in Arithmetic, numbers are represented by *figures*, each figure having only one meaning; but in Algebra, numbers are represented by *letters*, and each letter may have any value we please, the only limitation being that, in any particular investigation, a letter keeps the same value throughout. Since the letters may have any value whatever, the results obtained must be equally true of all numbers. Thus, in Algebra, we are able to *generalisé* the results obtained in Arithmetic.

2. The chief operations are the same as in Arithmetic—*viz.*, addition, subtraction, multiplication, division, and are expressed by the same signs, $+$, $-$, $\times$, $\div$. Thus, $a+b$ means that the number which is represented by b is to be added to the number which is represented by a. Similarly, $a-b$ means that the number represented by b is to be subtracted from the number represented by a. If we do not know the actual numbers which a and b represent, we can go no further than writing the results in the form $a+b$ and $a-b$ respectively. When two letters, or a number and a letter, are to be multiplied together, the multiplication sign is usually omitted, or it may be replaced by a dot. Thus, $a\times b$ may be written either in the form $a.b$ or ab. The latter is more usual. Similarly, $3\times x\times y\times z$ is contracted into $3xyz$.

As in Arithmetic, division is also denoted by writing the dividend above the divisor, with a line between them, so that $a\div b$ and $\frac{a}{b}$ each mean that a is to be divided by b.

3. When two numbers are multiplied together the result is called the product; or, if more than two are multiplied, the *continued product*. Each number is called a factor of the product.

If we separate the factors into two groups, either group is called the co-factor, or the *co-efficient*, of the other. If one of the factors is expressed in figures it is called the *numerical coefficient* of the other factors.

In the product $3xyz$, 3 is the numerical coefficient, xy is the coefficient of $3z$, z is the coefficient of $3xy$, and so on.

The definitions of *power*, *index* (or *exponent*) and *root* given in Arts. **138** and **139** of Arithmetic also apply to Algebra.

Thus, the fifth power of a means $a\times a\times a\times a\times a$, and this is abbreviated into a^5, and read "a to the fifth."

4. An *algebraical expression* is a collection of symbols, such as $3x^2y+4xyz\div 2z-6$. The parts of an expression which are connected by the signs $+$ and $-$ are called its *terms*. Thus, the above expression consists of three terms—*viz.*, $3x^2y$, $4xyz\div 2z$, and 6. It should particularly be noticed that $4xyz\div 2z$ is *one* term, so that $4xyz$ is to be divided by $2z$ *first*, and the result added to $3x^2y$. From this last result, 6 is to be subtracted.

This explains the reason for the statement in Art. **87** of Arithmetic. In the example there given $\frac{3}{4}\div\frac{7}{8}$ forms one term of the expression $\frac{3}{4}\div\frac{7}{8}+\frac{5}{3}$, and therefore its value must be found before the remaining term can be added to it.

5. A *simple* expression, or monomial, contains only one term; a *compound* expression contains more than one. A compound expression of *two* terms is also called a *binomial* expression; one of *three* terms is a *trinomial;* one of *more than three* is a *multinomial.*

6. Brackets are used in the same way as in Arithmetic [Art. **84**]. In addition to the ordinary forms of brackets, a straight line called a *vinculum* is used. The line is drawn over the expression which is to be treated as a whole; thus, $2a-(c-\overline{a+b})$ has the same meaning as $2a-\{c-(a+b)\}$.

SUBSTITUTIONS

7. We shall now work examples to illustrate the foregoing definitions.

Example 1. If $x=3$, what is the value of (i.) x^4, (ii.) $4x$?

x^4 means the continued product of four quantities each equal to x.

$$\begin{aligned}\therefore x^4 &= x\times x\times x\times x\\ &= 3\times 3\times 3\times 3\\ &= \underline{81\ \textit{Ans.}}\end{aligned}$$

$4x$ means the product of the two factors 4 and x.

$$\begin{aligned}\therefore 4x &= 4\times x\\ &= 4\times 3\\ &= \underline{12\ \textit{Ans.}}\end{aligned}$$

Example 2. If $a=1$, $b=2$, $c=3$, find the value of $5abc^2$.

$$\begin{aligned}5abc^2 &= 5\times a\times b\times c\times c\\ &= 5\times 1\times 2\times 3\times 3\\ &= \underline{90\ \textit{Ans.}}\end{aligned}$$

Note that the index, 2, only refers to the letter after which it is written. $5abc^2$ does *not* mean that we are to find the value of $5abc$ and square the result.

Example 3. If $a=5$ and $b=2$, find value of $\sqrt{5a^2-b^2}$.

$$\begin{aligned}\sqrt{5a^2-b^2} &= \sqrt{5.a.a-b.b}=\sqrt{5.5.5-2.2}\\ &= \sqrt{125-4}=\sqrt{121}=11\ \textit{Ans.}\end{aligned}$$

Example 4. When $x = 2$, $y = 1$, and $z = 3$, show that

$$\frac{3x + y - z}{x - 2y + z} - \frac{\sqrt{x^2 + 3y + z^2}}{\sqrt[3]{5x^3 - 3y^3 + z^3}} = \frac{y}{z}.$$

The expression on the left

$$= \frac{6 + 1 - 3}{2 - 2 + 3} - \frac{\sqrt{4 + 3 + 9}}{\sqrt[3]{40 - 3 + 27}}$$

$$= \frac{4}{3} - \frac{\sqrt{16}}{\sqrt[3]{64}} = \frac{4}{3} - \frac{4}{4} = 1\tfrac{1}{3} - 1 = \tfrac{1}{3} = \frac{y}{z}.$$

Example 5. If $x = 5$ and $y = 2$, find the value of

$$2x - [1 + 3(x - \overline{1 + y})].$$

The given expression

$$= 10 - [1 + 3(5 - \overline{1 + 2})]$$
$$= 10 - [1 + 3(5 - 3)]$$
$$= 10 - [1 + 3 . 2]$$
$$= 10 - [1 + 6]$$
$$= 10 - 7 = 3 \ \textit{Ans.}$$

After substituting the values of the letters, we proceed exactly as in the example worked out in Art. **84** of Arithmetic.

8. If one factor of a product is 0, the product itself will be 0. Also, any power of 0 is 0. Hence, if we are required to find the value of such an expression as $a^2bx + 3ab^3 + 4a^2x^2$, when $a = 3$, $b = 2$, and $x = 0$, we neglect all terms containing the factor x. Thus, the required value is that of $3ab^3$, or $3 . 3 . 2^3$, which equals 72.

EXAMPLES 1

If $a = 3$, $b = 1$, $c = 2$, find the value of

1. $3a$ **2.** $4abc^2$.

3. $a^3 + b^3 + c^3 - 3abc$. **4.** $\dfrac{a + b - c}{a + c - b}$.

5. $\frac{1}{2}a^2b^2c^3 - \frac{1}{3}a^3bc$.

If $x = 6$, $y = 3$, $z = \frac{1}{2}$, find the value of

6. $\sqrt{2x^2 + 3y^2 + 4z^2}$. **7.** $\sqrt[3]{\dfrac{3xy}{z^2}}$.

8. $\sqrt{x + y} \ . \ \sqrt[3]{x + 4y^2 + 7z^3}$.

9. Show that $x^2 - 7x + 12$ is equal to 0 when $x = 3$, and also when $x = 4$. Find its value when $x = 5$.

10. If $a = 4$, $b = 2$, $c = 1$, and $d = 0$, find the value of $(ad + bc)^2 - 2(2a^2 - 3b^3) + (cd - 2b)^2$.

POSITIVE AND NEGATIVE QUANTITIES

9. The signs + and − have, in Algebra, a wider meaning than in Arithmetic. They are used to denote a *quality* of the quantities before which they are placed. Many quantities may imply either an *increase* or a *decrease*. For example, a sum of money may be received, or it may be paid. Hence, we agree that a quantity which *increases* the quantity we are considering shall be called a *positive quantity*, and have the sign + prefixed; while a quantity which *decreases* the quantity we are considering shall be called a *negative quantity*, and have the sign − prefixed. Thus, in calculating the amount of money a man is worth, + £5 will stand for £5 which he possesses, or which is to be paid to him; while − £5 will stand for £5 which he himself owes. But, if we are estimating the man's *debts*, + £5 will stand for £5 which he owes, while − £5 will stand for £5 which is owing to him.

10. Used in this sense, the sign + is often omitted, so that, when no sign is written before a term, the sign + is understood.

The necessity for distinguishing between positive and negative quantities has led to the word "sign" being applied only to the + and −, and not to the × and ÷. Thus, when we speak of *the sign* of a quantity, we mean the + or the − placed before it.

11. The magnitude of a quantity, considered independently of its sign is called its *absolute magnitude*.

ADDITION

12. When two terms contain the same letters, and the corresponding letters in each term are raised to the same power, they are called *like* terms. If the corresponding letters are not raised to the same power, they are called *unlike* terms.

Thus, $4xy^3z^2$ and $-2xy^3z^2$ are *like* terms, since each contains the letters x, y, z, and x is raised to the first power in each, y to the third power, and z to the second power. But $3a^2b$ and $2ab^2$ are *unlike* terms, since, although they contain the same letters, the letters are not raised to the same power in each.

13. A positive quantity makes an increase, and a negative quantity a decrease. Hence, to add a positive quantity to any expression, we *add* its absolute magnitude; and, to add a negative quantity, we *subtract* its absolute magnitude.

Thus, if we add $+ 2a$ to $+ 3a$ we get $+ 2a + 3a$; while, if we add $- 2a$ to $+ 3a$, we get $+ 3a - 2a$.

Therefore, *to add a term to an expression, write the term after the expression, with its sign unchanged.*

Again, it is clear that to add an *expression* gives the same result as if we add the *terms* of the expression separately.

For example, if we add the expression $a + b - c$ to x we shall obtain the same result as if we first add the term $+ a$ to x, then the term $+ b$, and finally, the term $- c$.

Hence, *to add two or more algebraical expressions together, write down all the terms in succession, with their signs unchanged.*

14. After writing down all the terms we must collect together all terms which are *like* [Art. **12**].

For this, we have the following rules:

1. The sum of like terms is a like term.
2. If the terms all have the same sign, add the coefficients. Prefix the same sign to the result. This will be the coefficient of the sum.
3. When some of the like terms are positive, and some negative, (i.) add the coefficients of the positive terms; (ii.) add the coefficients of the negative terms; (iii.) take the difference of these results, and prefix the sign of the greater. This gives the coefficient of the sum.

Example 1. Add together a^2, $5a^2$, $9a^2$, $11a^2$.

$$a^2 + 5a^2 + 9a^2 + 11a^2$$
$$= (1 + 5 + 9 + 11)a^2$$
$$= 26a^2 \ \textit{Ans.}$$

We add together the four coefficients—*viz.*, $+1$, $+5$, $+9$, $+11$, giving $+26$ for the coefficient of a^2 in the required sum.

Example 2. Find the sum of $-12x^2y$, $-4x^2y$, and $-17x^2y$.

$$-12x^2y-4x^2y-17x^2y$$
$$=-(12+4+17)x^2y$$
$$=-33x^2y \quad Ans.$$

Add together 12, 4, and 17, and put the same sign, *viz.*, $-$, before the result; giving -33 for the coefficient of x^2y.

Example 3. Add together $5abc$, $-9abc$, $-2abc$, $3abc$, $-4abc$.

$$5abc-9abc-2abc+3abc-4abc$$
$$=8abc-15abc$$
$$=-7abc \quad Ans.$$

We find the sum of the positive terms as in Ex. 1, and the sum of the negative terms as in Ex. 2. Finally, to obtain the sum of $8abc$ and $-15abc$, we take the difference between 8 and 15, and prefix the sign of the greater number, the result being $-7abc$.

15. When the expressions to be added contain several sets of like terms, we proceed as above with each set separately.

Example 1. Add together $4bc-3ca+ab$, $5ca-6ab$, $-7bc+ca+2ab$.

The sum

$$=4bc-3ca+ab+5ca-6ab-7bc+ca+2ab$$
$$=\underbrace{4bc-7bc}\underbrace{-3ca+5ca+ca}\underbrace{+ab-6ab+2ab}$$
$$=\quad -3bc \qquad +3ca \qquad -3ab \quad Ans.$$

NOTE. The second line of work is merely a rearrangement of the first, and is not necessary. It is introduced to show clearly how the third line is obtained.

It is more usual to arrange the terms in columns, with like terms in the same column.

The above example then appears thus:

$$\begin{array}{rrr} 4bc & -3ca & +ab \\ & 5ca & -6ab \\ -7bc & +ca & +2ab \\ \hline -3bc & +3ca & -3ab \quad Ans. \end{array}$$

Generally, we combine the terms in the left-hand column first, and so on, working from left to right; but this, of course, is quite optional.

Example 2. Find the sum of $\frac{3}{2}a^2b-\frac{1}{4}ab^2+a^3$, $\frac{1}{2}a^3-\frac{1}{4}a^2b+\frac{3}{2}ab^2$, ab^2-a^2b.

$$\begin{array}{rrr} \frac{3}{2}a^2b & -\frac{1}{4}ab^2 & +a^3 \\ -\frac{1}{4}a^2b & +\frac{3}{2}ab^2 & +\frac{1}{2}a^3 \\ -a^2b & +ab^2 & \\ \hline \frac{1}{4}a^2b & +\frac{9}{4}ab^2 & +\frac{3}{2}a^3 \quad Ans. \end{array}$$

We have a column for the terms a^2b, another for ab^2, and a third for a^3. In writing the columns, note that we have to insert the sign $+$ before $\frac{1}{2}a^3$ and before ab^2, these terms having no sign in the given expressions, $+$ being therefore understood [Art. **10**]. If the fractional coefficients cannot be added mentally, we proceed as in Arts. **80** and **81** of Arithmetic.

SUBTRACTION

16. Subtraction is the reverse of addition. Therefore, if to some expression we first add a quantity, and then subtract the same quantity, the expression remains unaltered.

Hence, $x+y-y$ is the same as x.

Now, if from the expression $x+y-y$ we take away the $+y$, we have $x-y$ left. That is, if we take away $+y$ from x we have $x-y$ left.

Similarly, if from $x+y-y$ we take away the $-y$, we have $x+y$ left. That is, if we take away $-y$ from x we have $x+y$ left.

We have, therefore, these two results,

$$x-(+y)=x-y$$
$$x-(-y)=x+y$$

from which we obtain the rule: *To subtract a term from a given expression, write it after the given expression, but with its sign changed.*

Again, to subtract an expression as a whole will plainly give the same result as subtracting the terms of the expression separately.

Hence: *To subtract one expression from another, write all the terms of the one expression after the other expression, but with their signs changed.*

17. After writing down the terms, we collect like terms exactly as in addition.

Example 1. From $5x-2y+z$ take $-x+3y-z$.

Writing the second expression, with all the signs changed, after the first expression, we get

$$5x-2y+z+x-3y+z$$
$$=6x-5y+2z \quad Ans.$$

The work is often arranged as for addition, the expression to be subtracted being written underneath the other, with like terms under like terms. The signs of the lower line are changed *mentally*.

The above example then appears thus,

$$\begin{array}{lrrr} \text{From} & 5x & -2y & +z \\ \text{take} & -x & +3y & -z \\ \hline & 6x & -5y & +2z \quad Ans. \end{array}$$

Say, $+x$ and $5x = 6x$
$-3y$ and $-2y = -5y$
$+z$ and $z = 2z$.

Example 2. Subtract $x^3-2x^2y+y^3$ from $-x^3+2xy^2+2y^3$.

$$\begin{array}{lrrrr} \text{From} & -x^3 & & +2xy^2 & +2y^3 \\ \text{take} & x^3 & -2x^2y & & +y^3 \\ \hline & -2x^3 & +2x^2y & +2xy^2 & +y^3 \quad Ans. \end{array}$$

Say, $-x^3$ and $-x^3=-2x^3$
$+2x^2y$ and $0=2x^2y$

and so on.

EXAMPLES 2

Find the sum of

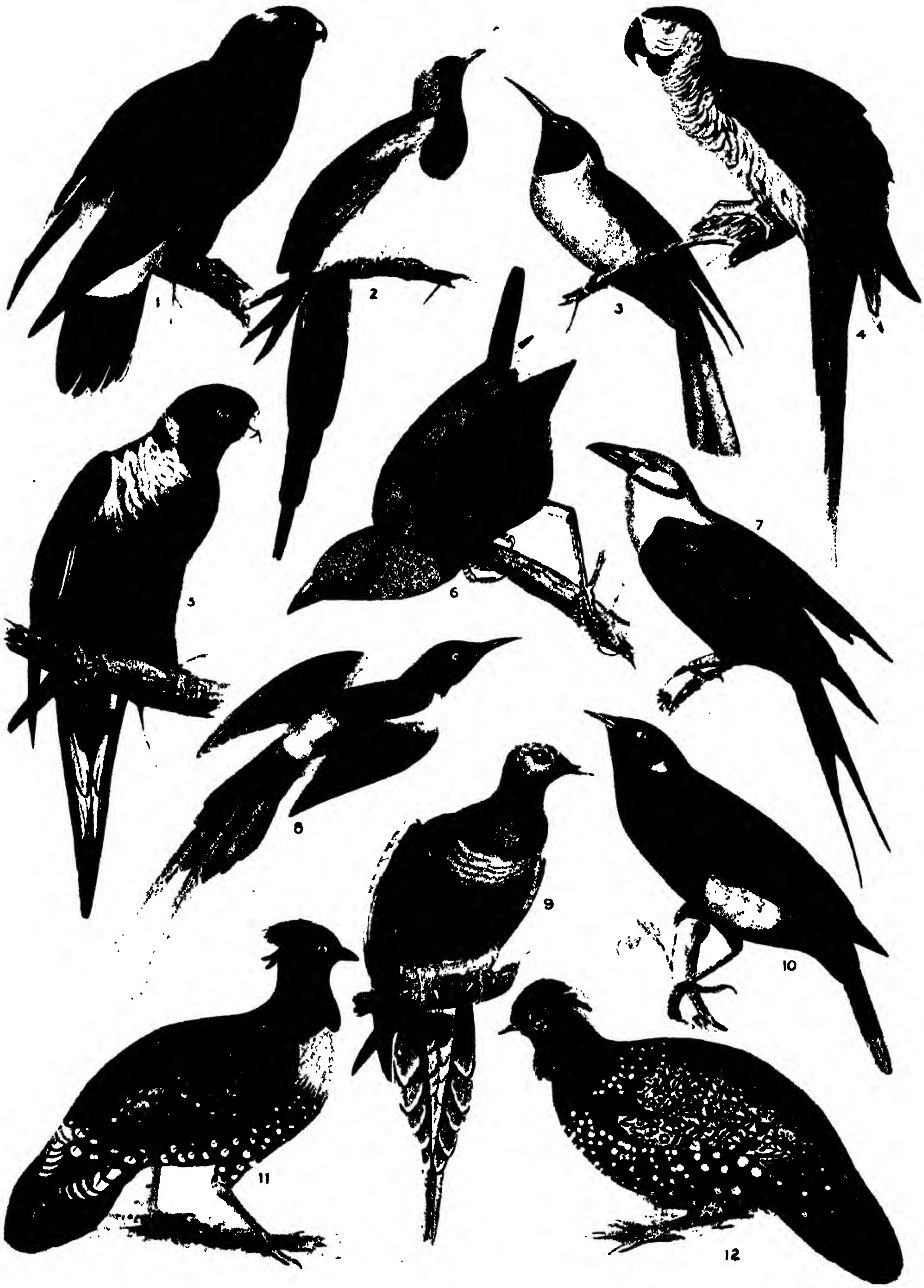
1. $3ab+2ca-6bc$; $-4ab+ca+3bc$; $2ab-2ca+4bc$.
2. x^3-2x^2+1; $3x+4x^2-2x^3$; $-5-2x$; $-3x^2-x^3+6$.
3. $\frac{2}{3}x-\frac{4}{5}y+\frac{5}{6}z$; $-\frac{1}{9}x+\frac{3}{10}y-\frac{1}{12}z$; $-\frac{1}{18}x-\frac{3}{10}y-\frac{1}{4}z$.
4. $ax^2-a^3+3x^3$; $2a^2x+x^3-4ax^2$; $3a^3-5x^3$; $2ax^2-3a^2x+a^3+x^3$; $-ax^2-a^2x-3a^3$.

Subtract

5. $ab+cd-bd$ from $-ab-2cd+3bd$.
6. $5x^2y-3xy^2+x^3$ from $2xy^2-3x^2y-y^3$.
7. $\frac{1}{2}a+\frac{1}{3}b-\frac{1}{4}c$ from $\frac{1}{3}a-\frac{1}{4}b+\frac{1}{2}c$.
8. $6a^4-2a+3-a^2$ from $a-1+3a^3-a^4$.
9. From the sum of $7x-4+3x^2$ and $2x^3-4x+1$ take x^3-x^2+x-1.
10. Add the sum of $3y-y^3+2$ and $1-4y^2-y$ to the remainder left when $3y-6y^3$ is subtracted from $1-2y$.

H. J. ALLPORT

THE BEAUTIFUL PLUMAGE OF BIRDS



EXAMPLES OF THE GORGEOUS COLOURING OF BIRDS

1. Kuhl's coriphilus
2. Cape dove
3. Blue-bellied bee-eater
4. Blue-and-yellow macaw
5. Swainson's lorikeet
6. Flame-headed weaver
7. Blue-bodied roller
8. Red-tailed sunbird
9. Sharp-tailed vinago
10. Golden-eared grackle
11. Golden-breasted tragopan
12. Nepal or horned tragopan

PLATE FACING 2195

The Neglect by Modern Youth of the Easiest Avenue to Success

HARD WORK

THE world today is full of young men who profess to be ambitious to win success, who declare that they are looking out for opportunity, but opportunity never comes, and they go on from year to year without making any appreciable progress, while here and there an associate of theirs gets right ahead, and, after a comparatively short time, reaches a summit of success in his sphere.

Probably not one in a hundred of the men who enter business, or practise art, literature, or the learned professions, can be said to attain a real success. The prizes go to the few; the others bemoan their unfortunate lot, and complain that they have never had the chance they deserve and have waited for. Why is it so few are successful in any real sense of the word? Why is it so few reach substantial incomes, discover things, achieve triumphs, become kings in literature, or art, or commerce?

It is surprising that the number of successful men is not larger than it is, for, while there is a hopeless struggle at the foot of the ladder, there is always plenty of room at the top, and yet very few make any resolute attempt to get there. If the man who earnestly determines to be successful cannot find a position for himself already existing, he very soon makes one. A substantial degree of success is not an ideal possible only for a few; it is a path open to many, if they will only learn the true secret of its ascent.

The primary secret of success certainly is not genius, for very few of those who are regarded as the world's successful men can be described as geniuses. It is not heredity, nor yet the advantages of early youth, for many of the greatest men in science and art and literature and commerce have been children of poor, uneducated parents, and, so far from having enjoyed advantages in youth, have suffered every disadvantage and met with every possible obstacle. The real secret of success does not lie in anything outside the man himself, and this makes it all the more amazing that with such a prize within reach so few men make any really serious effort to obtain it.

The most readily available avenue to success is hard work. Nearly every instance of a man who has gone to the top in his profession or business is a proof of this. The world's great artists have not picked up a brush and in a moment of inspiration dashed off a masterpiece. Most of the pictures that are the admiration of the world today were painted, added to, altered, improved, and worked upon till the artists felt they would never have their tasks finished. The world's scientists and inventors did not hit upon their great discoveries by a happy intuition. They worked and studied by day and by night, never flagging in their energy, and often by sheer hard work, as well as by genius, wrested from Nature's jealous grasp secrets which have been of inestimable value to mankind. The world's great literary masterpieces have not been written in a moment. They represent the result of toil such as most of the people who read and enjoy them know nothing of. It is said that Walter Pater rewrote one of his most brilliant books, "Marius the Epicurean," no fewer than ten times! And the great businesses of the world, the citadels of commerce, which are the mainstay of all civilised nations, are essentially monuments of hard, and even of weary, toil.

Hard work is the most easily followed avenue to success, and yet how few there are who ever have made use of it to attain the success and power and wealth they envy in men who have used it to the full!

All great employers of labour, all in places of power and profit in the outstanding businesses of the land, are only too well aware that the young men of today are not willing to work hard. They have too many interests outside their businesses, and only one here and there puts work first. When business clashes with these interests, then business must be put in the second place, say many of these aspirants for success.

In one thing they never fail, and that is in keeping rigidly to the hour of departure from the office. Nor do they err at the other end of the day and start work ten minutes before the hour for beginning. They are like Charles Lamb, who, when he was reprimanded by his chief at the India House with the words, "Mr. Lamb, you always come late," replied, "Yes, sir, but I always go early."

If there is an unusual rush, unless it is compulsory for the clerks and others to remain and finish the work, very few would dream of staying, much less think of putting off an engagement in order that the work of their employers should be properly completed. Even those who take a high moral or religious stand are often as reprehensible as those who profess to live only for their own pleasure. And yet surely the truest religion, apart from any question of success that may result from hard work, is to give the very best of one's time and talents to the service of the firm which provides one's livelihood.

It is because the young men of today are afraid of work that they are not succeeding like those who have already come to the front. There never was a time when employers were more on the look-out for good men to put in positions of responsibility and profit, but such men are difficult to find. The man who works hard today has a splendid opportunity, but thousands fail because they are not prepared in an emergency cheerfully to do a little extra; other interests crowd out those of business.

Only the other day a young man was complaining that he was not getting on fast enough, and when, a couple of days later, his chief asked him to stay for five minutes in order to type just one letter so that it might catch the post that evening, he showed unmistakably that he was annoyed, although he had not the courage to say he did not wish to stay. That kind of conduct is more irritating to an employer than a downright refusal. And yet the man in question is a good worker, and has the possibilities of success lying dormant within himself. He can do well, he could do better, but he fails because he is not prepared cheerfully to do a little extra work in an emergency. So he will jog along on a small salary, probably, all his days, and may really be written down as one of life's failures.

He is firmly convinced that when he has put in his eight hours of attendance at the office his employer has no further claim upon his services. He quite overlooks the fact that he often steals ten minutes of his employer's time at the luncheon interval, that he gets certain additional advantages not specified in his bond holidays on a full salary, a bonus at Christmas, and so on all of which are extras due to the generosity of the employer; and these he has come to look upon as his right. The man has good points, but as he fails to be a hard worker he will never be a real success.

We hear a great deal about sweating and speeding-up, but the men who work hardest in offices and business houses are not the ordinary members of the staff, but the heads of departments. The work of these men is never done. They usually start earlier and end later than their subordinates, and then when they leave the office they have not finished, for they take work home; and it is by this constant and persistent devotion to the work in which they are engaged that they have achieved their success.

Much is said and written about the dignity of labour, but it is only the man who takes a real interest in his work who feels the dignity of it. So many men seem ashamed of work—and this equally applies to women—and yet life shows that the noblest people have always been the hardest workers.

"We read in Homer," says one writer, "of princesses themselves drawing water from springs, and washing with their own hands the linen of their respective families. Here the sisters of Alexander—that is, the daughters of a powerful prince—are employed in making clothes for their brother. The celebrated Lucretia used to spin in the midst of her female attendants. Augustus, who was sovereign of the world, wore for several years together no other clothes but what his wife and sister made him. It was a custom in the northern parts of the world for the princes who then sat upon the throne to prepare several of the dishes at every meal."

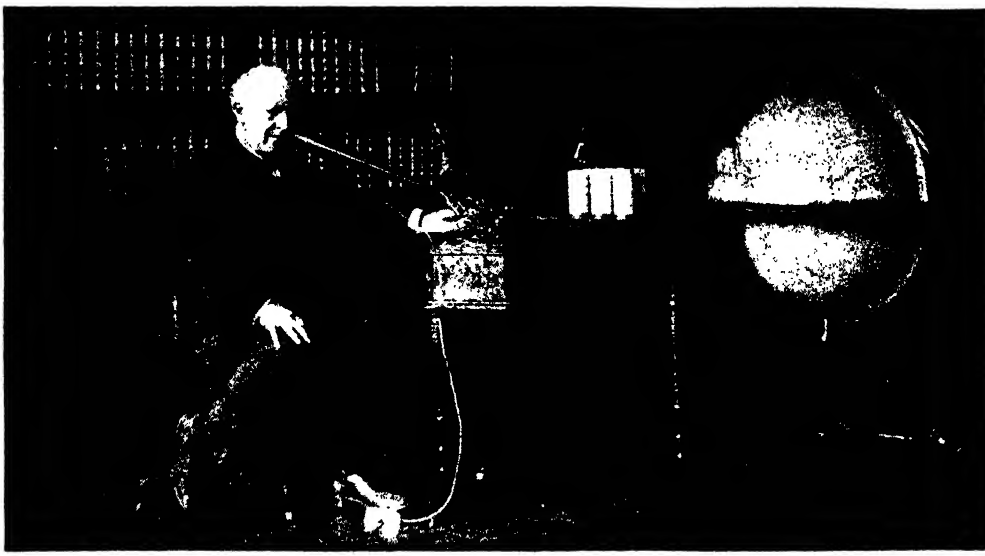
It is astonishing how hard work can give a zest to all a man's life. Professor Max Müller once wrote to a friend: "Work is life to me, and when I am no longer able to work life will be a heavy burden." How many of the young men of today feel like that? It was the same

distinguished man who, realising that work is the real secret of success, said: "To delight in doing one's work in life—that is what helps one on."

This question of hard work is one with which every man should concern himself from youth upwards, for sooner or later he will have to work hard, whether he likes it or not. If he works hard in his young days, and, as a result, attains success, he will probably be able to slow down and have an easier time when age creeps upon him and he is less fitted for strenuous exertion. On the other hand, if he is lazy in his youth, and, on account of his laziness, fails to obtain that success that comes most readily through industry, then when he gets on in years, and has failed to attain to a position of profit and responsibility, he will find that in order to earn a bare subsistence he will have to work harder and harder. This is the irony of the whole business, and should act as an incentive to every intelligent young man as he studies the life that lies before him.

Directly he leaves school he should begin to be an energetic worker. His education is far from complete, even though he have carried off all the prizes from his fellow-scholars. A man can never know too much, and by study a young man can in his spare time go on fitting himself for the position that may be offered to him when he is efficient.

The expression "self-made," used of so many of the successful men of the world, is an excellent one; for, after all, it is true that a man makes his own career. He makes or mars himself, and success depends not so much upon outside opportunity, although that may come to every man, but upon a man's fitness to take it however it comes. Many a youth who has frittered away his evenings has had cause to regret the fact when a position has become vacant and he has been unable through incompetency to fill it. He has failed when he had the time to learn shorthand or bookkeeping, or some other useful subject. He has, in fact, failed to be a hard worker, and he is passed by when he might have been promoted had he possessed the qualifications which nothing but his own laziness has deprived him of.



THOMAS EDISON AT WORK EXPERIMENTING WITH AN IMPROVED PHONOGRAPH

The whole matter has been put very tellingly, if somewhat crudely, by an American writer. "Boys are constantly writing me," he says, "for advice about how to succeed, and, when I send them my recipe, they say that I am dealing out commonplace generalities. Of course I am, but that's what the recipe calls for; and if a boy will take these commonplace generalities and knead them into his job, the mixture'll be cake. Once a fellow's got the primary business virtues cemented into his character, he's safe to build on."

CHARLES RAY

Russia's Inland Sea Coast, Flat Surface, and Large River Basins. Climate. Zones of Vegetation. Industries. Baltic Lands and Poland.

RUSSIA IN EUROPE

Boundaries. European Russia (2,100,000 sq. miles) stretches eastwards from an artificially determined land frontier with Norway, Sweden, Germany, Austria-Hungary, and Rumania, to the confines of Asia. Its northern shores are washed by the Arctic Ocean and its gulf, the White Sea, on which is Archangel, long the only Russian port, closed by ice for half the year. On the Baltic Sea, in the north-west, are the ports of St. Petersburg, Revel, Libau, and Riga, of which only Libau is always open. In the south the Black Sea, with Odessa as its chief port, communicates with the Mediterranean, an advantage lessened by the fact that Constantinople commands the only exit and entrance. The land-locked Caspian facilitates communication and trade with Persia on the southern shore and with the Russian dominions in Central Asia.

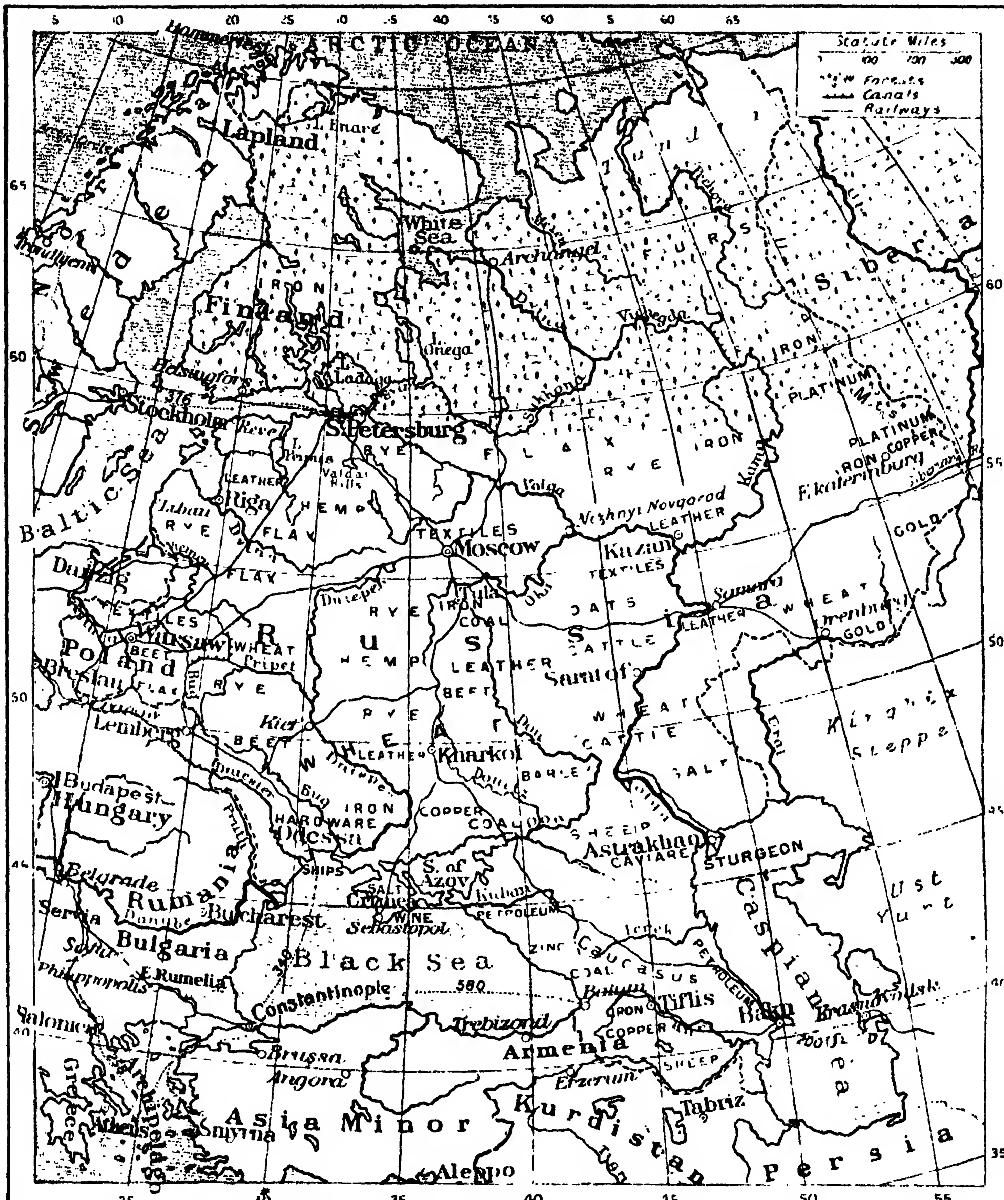
A Surface Nearly Level. Russia has no striking contrasts of highland and lowland. It is an undulating plain, generally over 300 feet above sea level, crossed by a broad belt of higher ground which rises in the Valdai Hills to 1,100 feet, and forms the divide between the rivers flowing to the Arctic and those flowing to the Baltic, Black, and Caspian Seas. The Urals, which form part of the boundary between Europe and Asia, consist in the south of parallel ridges rising to 4,500 ft., but are less definite in the north, where, in spite of an elevation of 5,000 ft., they may be regarded as a continuation of the central belt of elevation. They are extraordinarily rich in minerals, including iron, and the forests supply all the timber needed for smelting it, as well as an immense surplus for export. This is made up into huge rafts, which are floated down the Kama and its tributaries to the Volga. The Caucasus, which forms the frontier of Europe between the Black and Caspian Seas, rises in Elbruz to 18,000 ft., and contains many extinct volcanoes. The scenery rivals that of the Alps in beauty, glacier and snow-peak rising above the beech forests and pastures which clothe the lower slopes.

Russia's Big Waterways. The rivers of Russia, though they diverge to widely distant seas, rise near each other at the same level, and often in the same vast marshes. Flowing across a region with no strongly marked natural features, their courses often approach each other, so that it is easy to traverse the country from end to end by water, the boats being carried for a short distance across the low, marshy land which separates one river from another. Canals connect the various rivers, so that there is a continuous waterway, for example, between St. Petersburg on the Baltic and Astrakhan on the Caspian.

Look out on the map the sources of the North Dvina, flowing to the Arctic; the Volga, flowing first east and then south, round the base of low heights, and across sunken plains to the Caspian, which lies below sea-level; the Western Dvina, flowing west to the Gulf of Finland; and the Dnieper, which flows south to the Black Sea, and helps to drain the great Pripet swamp, the rest of whose waters are carried to the Baltic by the Vistula. Between the Vistula and the Western Dvina is the Niemen, whose chief tributary rises only a few miles from a tributary of the Dnieper. All these rivers are near each other either at their sources or in other parts of their course. The country between the Dnieper and the Volga is drained to the Sea of Azov by the Don and its tributary, the Donetz. Notice the close resemblance between the lower courses of the Dnieper, Don, and Donetz, and how this eastern trend brings the Don within 40 miles of the Volga, rendering communication between the Caspian and Black Seas easy and cheap. The other rivers to note are those from the Urals, the Pechora, flowing north to the Arctic, and the Ural, south to the Caspian, forming part of the boundary of Europe.

Climate. In Russia we have a typical continental climate, dry and extreme, especially in the east. The rainfall of Russia is everywhere scanty, except in the Western Caucasus, and the districts round the Caspian are almost rainless. Look back at the climate maps of Europe. The great southern sweep of the winter isotherms means that everywhere the winter is long and severe. A hundred years ago Russia utterly defeated the great Napoleon by the aid of two invincible generals, General January and General February. There are no high hills to break the winter gales which sweep across the country with irresistible force, making the winters of such neighbouring countries as Rumania much more severe than if mountains intervened. Snow covers the whole country for many weeks, and the frosts become more intense and protracted as we go east. The rivers are frozen for six months in the north, three or four in the centre, and for eight or ten weeks in the south. At Astrakhan, in the latitude of Lyons, the ice lasts 90 days; while at Warsaw, on the Vistula, which, though much further north, is also further west, it lasts only 77.

The Coming of Spring. After this long winter, spring comes and goes in a flash. "The sound of many waters is heard everywhere as the melting snow flows down to the low-lying fields, converting miles of country into a shallow lake, in which the farms and villages built on a little higher ground seem an archipelago of islands. For ten days or a fortnight all communication



INDUSTRIAL MAP OF RUSSIA IN EUROPE

ceases with the outer world." Almost immediately it is the height of summer. "A few days after the frost has disappeared the trees are all in leaf. Within the space of a few yards I have often seen the ground a blaze of flowers and butterflies and dragonflies skimming over heaps of snow that the fierce rays of the sun have not had time to melt." The summer is hotter in the south than in the north, and in the east than the west. So precious is the summer that many peasants, all of whom cultivate a fraction of the soil, hasten from the factories where they have spent the winter, to sow and reap from dawn to dusk, returning to the mills when the leaves begin to fall and the night frosts tell of returning winter. The hard-earned gains of the summer often provide for a life of idleness in the winter, when the peasant passes his time lying on the *pech* or stove in his house, the monotony of this occupation being broken now and then by the advent of some wandering minstrel, reciting legends of the country. The agricultural machinery is largely imported from England and America.

Zones of Vegetation. Russia extends across the whole breadth of Europe, and has all those zones of vegetation which we have so far

seen only separately. In the north is the tundra, but on a vaster scale than in Norway or Sweden. Across a desolate, treeless, marshy plain, buried half the year in snow, the rivers creep to the Arctic. Fishing in river and sea is important in summer, and in winter timber is cut, and fur animals are hunted in the forest to the south. The preparation of timber, tar, pitch, furs and tallow from the forests, and of train oil from the Arctic fisheries are the chief occupations. Archangel, the port of the tundra, trades in all these.

The coniferous forests of Sweden and the deciduous forests of Central Europe are found in Russia on a magnificent scale. Villages and towns are built in the clearings, and all around lies the boundless forest, with the river as its most practicable highway.

South of the forest belt are the agricultural lands, passing into rich steppes like those of Hungary and Rumania, but infinitely greater in extent. On the margin, the landscape is broken by small woods, but the true steppe is treeless, and grass or ploughed lands extend to the horizon. Much of the steppe is covered with rich black earth of inexhaustible fertility. Its beauty and fascination for the steppe dwellers have already been described.

Finally, beyond the steppes comes what is not found elsewhere in Europe, the beginning of the desert in the dry, salt plains round the Caspian. This region is as thinly peopled as the tundra, and offers as little to its inhabitants.

Occupations. The uniformity of the surface has its counterpart in the lives of the people, among whom we find little of that diversity which marks Western Europe. The occupations of the tundra depend on the fisheries and the forest. In the forest regions the forest industries are carried on, with agriculture in the clearings. Agriculture is all important south of the forest zone during the summer, and the cultivated steppes form one of the granaries of the world. In winter those peasants who remain in their villages carry on many industries, often of a highly-skilled character, supplying all peasant and many middle-class requirements. For this, among other reasons, large industrial towns are confined to the coalfields. These are found in Central Russia, round Moscow and Tula, the Sheffield of Russia, in the Donetz basin, and in Poland. The chief manufactures are distilling and brewing, cotton manufacture, sugar refining, tanning and flour milling.

The Baltic Lands. Around the Baltic lies a region of pine-woods and innumerable lakes, large, like Ladoga (7,000 sq. miles) and Onega (3,800 sq. miles), or quite small. Lying north of Ladoga and the Gulf of Finland is the grand duchy of Finland, with thousands of lakes. It is inhabited by a people whose intelligence, love of liberty, and prosperity, in spite of difficult natural conditions, recall the Swiss. The capital is Helsingfors, a handsome city opposite Revel. The latter is one of the ports of the Russian Baltic provinces, also a region of lakes and forests, with flax, hemp and hardier cereals in the clearings. These Baltic provinces are not Russian in blood, and to Russianise them St. Petersburg was built among the desolate swamps at the mouth of the Neva, the foundations being laid on piles. The Neva is frozen for nearly five months in the year. The city is handsomely built on both banks of the river, and is made picturesque by the coloured and gilded clustered domes of the cathedral of St. Isaac and of many churches. Kronstadt, at the head of the Gulf of Finland, strongly fortified, is the station of the Russian Navy, and an outport for the capital.

Poland. Poland, also non-Russian both in blood and sympathies, resembles the Baltic provinces in the north, but rises in the south to a densely-forested plateau, intersected by deep ravines. Agriculture and cattle breeding are important, and the forests supply timber, which is floated down the Vistula in great rafts. Coal and other minerals are abundant in the south, where industries are growing rapidly. Lodz, with a large proportion of Germans and Jews, has hundreds of cotton-mills, woollen factories, steam flour-mills, breweries, machine shops, etc. Warsaw, on the Vistula, the old capital, carries on many industries, and with its command of routes in all directions is bound to become one of the most important cities in Europe.

The Dnieper Basin. This lies partly in the unproductive zone of Central Russia, partly in the rich Black Earth belt. The sugar beet is grown round Kief, the chief city of the Dnieper, with sugar refineries, tanneries, woollen manufactures, and flour-mills, all manufacturing the products of the Dnieper basin. Kherson is the port. West of the Dnieper are Nikolaief, on the Bug, with similar manufactures, and Odessa, the commercial metropolis of the region, built on the high edge of the steppe above the Black Sea, and doing an enormous trade in the produce of the Black Earth region. Bessarabia in the south-west much resembles Rumania, and has many vineyards.

The Don Basin. The basin of the Don and its tributary the Donetz lies chiefly in the steppe region. Kharkof is the centre of the industrial region on the Donetz coalfield, which draws its raw materials from the steppes. The traffic in goods carried by the Don to Rostof and Taganrog, the ports of the Sea of Azof, is very great, including petroleum and other products of the Caspian, and timber from the Urals, which reach it by way of the Volga. The Crimea, united to the mainland by the narrow isthmus of Perekop, is a steppe land in the north, with a very extreme climate. In the south it rises to the Yaila Mountains (5,000 ft.), the southern valleys of which have the Mediterranean climate, and produce good wine.

The Volga Basin. The Volga, the largest river of Europe, 2,300 miles long, drains with its tributaries a region as large as the British Isles, France and Germany. It rises in marshes in the Valdai hills, and is navigable from Tver, where it leaves the hills. Nizhnyi Novgorod, the scene of an enormous annual

fair, where the products of east and west are exchanged, is built where the Oka comes in on the right bank, having flowed, like the main stream, through a densely forested region. On a tributary of the Oka is Moscow, the real centre of Russia, with its picturesque Kremlin Hill, crowned with palaces and churches. Farther south are the industrial centres of Tula and Orel, on the central coalfield. Below the confluence of the Oka the Volga flows between a high right and a low left bank. Kazan, the former Tartar capital, is on the river only in times of flood. Its power. Steam flour-milling is also important. The chief towns are Samara, on the left bank, and Saratov and Tsaritsin, on the right. At the latter town, from which a short railway goes to the Don, the river is already 60 ft. below the sea-level. A large branch, the Akhtuba, flows parallel to the main stream, communicating with it across marshy land by many channels. The delta begins 40 miles above Astrakhan, and is crossed by 200 distributaries. The valuable sturgeon and seal fisheries of the Lower Volga and Caspian employ thousands of men. Caviar, a delicacy

THE CATHEDRAL OF ST. BASIL, MOSCOW

industries are characteristic of the steppe towns, including tallow, soap, and candle works, and tanneries, utilising the produce of the vast herds of the steppe lands, also flour and starch mills, supplied by the agricultural steppes. The Kama, the chief tributary on the left bank, flows through the mining region of the forested Urals, and brings down the produce of Siberia, including immense quantities of grain and timber, as well as tea from the Far East. The lower course of the Volga is through the wheat land of the steppe. Windmills for grinding flour are everywhere, the country being too flat for water-made from sturgeon roe, is largely exported from Astrakhan. The chief occupation of the Caspian steppes, away from the river, is cattle keeping, carried on by nomadic tribes, who live in tents and follow their flocks and herds from pasture to pasture. Only along the river-banks and in the delta is there a settled population. Astrakhan is the Caspian port of the Volga; and an excellent system of canals in north-west Russia has converted St. Petersburg into its Baltic port, thus giving this immense but remote region an outlet to the markets of Central Europe.

A. J. and F. D. HERBERTSON

A MASTERPIECE BY AUBREY BEARDSLEY

AN ILLUSTRATION TO "THE RAPE OF THE LOCK"
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Choice of Work. How to "Block in." The Power of Line. Aids to the Artist's Career. Drawing from Life. The Human Form.

DRAWING & THE HUMAN FORM

The Artist's Choice of a Career. The student on the threshold of an artistic career should be very decided as to what branch of art he intends to master. If all his joy be in colour, he should give his strength to so mastering colour that it shall express the mood of the thing he wishes to create; and he should at the same time remember that there are other ways of painting, often vastly more lucrative, than the mere making of easel pictures. He should look to the career which will give him the greatest scope for his powers and the largest outlet for employment—such as the decoration of the walls of houses. Then, again, the illustrating of books and papers created some of the noblest art of the last fifty years. This field is to-day seriously damaged by the widespread use of photography; but photography can never compete with the creative artist in invention, and for the man of ideas there is still scope even in illustration, though the field is very limited. There is, on the other hand, wide scope for the employment of his art in advertisement such as the designing of the picture poster.

If, however, his joy be form, and he decide to be a sculptor, the same advice applies to him, for whilst his chances in selling the imaginative piece must always be limited, there is wide scope for him in the modelling of beautiful articles for everyday use and in creating decorative sculpture for buildings. In short, let nothing be too large or too small for the exercise of the artist's gifts—the more he does, the more facile will become his hand's skill in creation. There was never such a crying need for the beautifying of life by making every utensil and adornment in the home and in the street a joy to the eye.

What He Must Teach Himself. Having decided, then, on the province of art which he will make his own, the student is at once brought face to face with the serious question of training and pupilage. It is evident that the student will have to go through a certain amount of schooling in order to learn modelling in clay if he desire to become a sculptor, or the handling of paint if he wish to become a painter; but it is astounding how much he can learn even of these things in a short time, if he will first of all teach himself what he can alone learn by his own application and taste—to draw. Some men have risen to fame without more schooling in the arts than they could get from their own industry and the fellowship of other students. But whether a man be blessed with the inestimable advantages of seeing the great masters at work, or, better still, of working in their studios as pupil; or whether he may have to discover the craftsmanship of his art step by step for himself, there is one thing above all others that he *must* teach himself, and that is to draw with ease anything that may come his way, so that drawing becomes a habit. Drawing is to the artist what words are to him who would speak well; and just as a thorough grasp of English enables a man to speak it without any conscious effort, so a thorough mastery of detail should enable the artist to draw with such facility that his mind is not harassed by any of the countless difficulties which bewilder the student at the beginning.

The Habit of Drawing. This habit of drawing, which is at the base of everything that an artist does, which is in fact beneath every brushful of paint before that paint can be placed exactly where he wishes to place it, which is beneath the stroke of the chisel before the chisel can be made to yield form—this habit of drawing is the base and foundation of everything the artist does or may ever hope to do. And this art of drawing he *must teach himself*, whether he go to an art-school or become the pupil of a master, and by his own powers and gifts alone can he acquire it. He cannot begin too soon, for he must go through an ugly, hard, rigid stage of striving before the secret comes to him—nothing is too humble for him to draw. One day mastery may burst upon him almost as by magic, and he will find his hand drawing any form he desires to express, just as, in learning to read, his eye takes in the word without spelling it.

It is clear, therefore, that it is a waste of time to enter a class of painting before the hand can obey the will in its desire to express the form of things; let us therefore proceed to show the way along the road to art by showing what the student must teach himself; and when he is fit to take advantage of the schools we will lead him thither and through.

Drawing from Memory. Besides drawing direct from nature the student should practise from the outset memory drawing. He should try to record with his pencil what his eye has observed in street or field. And if he fail, let him go out and look again, and then correct his drawing until he is satisfied with the result. He will find this especially useful for the expression of movement, and his eye will soon acquire the custom of retaining each successive stage of rapid motion. This is the method of training followed by the Japanese, and in it lies the secret of the charm of Japanese art, which expresses with bold simplification the salient points which the eye can take in at a quick glance, omitting the detail which can only be observed in complete repose.

How to "Block in." The student's first step, then, is to use drawing as a habit. Now, the tendency of the beginner, when he starts to draw an object, is to begin with details, which is disastrous. He should first of all "block" in the mass, as it is called, then "block" in the mass of the detail, and then get the *accurate* forms. For instance, in sketching the human figure, first roughly sketch the main proportions so as to get the swing and action and general relations of the parts one to the other, to obtain the right proportions; then roughly sketch the general form of the details of the head and limbs; then with telling lines get the true form of the features and the wondrously beautiful lines of the limbs, so that, when even the outlines of the figure are drawn, they seem to hold the forms and state their character and suggest the underlying flesh.

A PORTRAIT BY HOLBEIN

It is a good thing—indeed, it is the best master in the wide world—to collect prints and cut out of old magazines good drawings by well-known artists, and to copy them—not only the work of one man, but the work of many, so as to learn to say with line what they could say. The choice of the masters will depend upon the taste of the student, but the chalk portrait-heads of Holbein, the many sketches in chalk by Lord Leighton, and the clear, firm drawings of such popular draughtsmen as Phil May, Randolph Caldecott, and the like are invaluable guides to drawing, whilst Sir Edward Poynter issued a series of drawing-books for students of the antique which are good training in chaste, clear line of the beauty of form to be learnt from the great Greek sculptors. It is capital practice, too, to get photographs of well-known people and of beautiful women, and to sketch them in line, always remembering to "block in" the whole head first, then to draw the details in their true relation to each other afterwards. Indeed, the very collecting of good examples of drawing will train the eye far better than all the directions that could be given.

Detail. The rough lines to "block out" the object are, needless to say, only to give a rough idea of where the real form will come; but when the details are drawn, then every line should be so true that the very object seems to be enclosed within them. In the first rough sketch of the general form and swing of the figure, for instance, we are only seeking to get proportion and the general idea of the ground to be covered. But the drawing of the detail that will then be set within this rough sketch cannot be too true or too beautiful in its effect upon the eye.

Exactly the same advice applies to a landscape. Rough-sketch the relation of things as a whole, roughly showing where the masses of dark and light will come, and the general lines. Then sketch in the details, which will not now get out of place.

It used to be the habit in the art schools to set a pupil to draw a Greek statue, and laboriously spend weeks and months in stippling and cross-hatching the light and shade of every detail of it, but this is a pitiful waste of power which should be applied to the acquiring of ease, deftness, and swiftness in setting down the form of things. And even if a student be attending an art school, all his work there will be empty of result if he is not constantly drawing as swiftly and well as he possibly can every object that he sees about him. Then, when the day comes that he awakes to find drawing a habit, he will not only be able to paint without being harassed with the difficulty of drawing, but he will be able to concentrate all his powers upon getting the colour true. Many a boy has come to hate literature because he was compelled to learn Shakespeare before he could understand him; in the same way art is choked out of many a lad by the boring and tedious effort to draw objects like old statuary until he hates every detail of the beautiful object.

Everything holds a character of its own, and that character can be given by drawing. It used, for instance, to be a stupid axiom amongst artists that trousers were without any character but that of stove-pipes, but men like Phil May came and proved that the lines and forms of trousers contained an astounding amount of character, whether they were the ragged wear of beggars, the dandified grotesqueness of costermongers, or the inherited breeches of street-boys. Boots hold a rare amount of the character of the feet they cover, character which they betray to the man with eyes sufficiently inquisitive to seek them out and draw them.

Line. Now as regards the line. The student should draw with the line as the musician uses a note of music on a violin—making the line swing out or thin down as it suits the form he would draw. It is an education to look at one of Holbein's chalk portraits to see how the line caresses the form of the brow, and seems to disappear over the curved edge, to start again

and sweep over the cheek-bone. The line as it forms the nose seems to search out every subtle curve and form, until it disappears into the flesh under the nostril. Then, again, take a pen-drawing by Aubrey Beardsley—see how musical is the sense it gives. When the line with its simple curve sweeps round the edge of the head, neck, and shoulders of some beautiful woman, it seems to be made of delicate flesh. It suddenly breaks into a series of dots that seem to be made of very muslin, tracing the delicate folds of gossamer draperies; then the line takes a stronger note and sweeps out the form of the silken gown, rippling along to make the flounces, and criss-crossing net-wise to state the net-like quality of some transparent veil. There is scarcely any master who could do more with the sheer beauty of his line than Beardsley, whose work is easily within the reach of any student. There are lessons innumerable in Randolph Caldecott's nursery books, not only of how line properly and fitly handled can *speak* to the eye, but also in the great beauty of colouring achieved by simple, broad washes of water-colour—an excellent practice which greatly enhances the value of a pencil-drawing, or of a drawing done with indelible black ink, which may be bought from any artists' colourman.

He should try to get a copy of the "Studio's" special number upon "Modern Pen Drawing," and Joseph Pennell's most useful volume on pen-drawing, with its invaluable examples by various artists, a book which is an education in itself, since it shows what wondrous beauty can be produced by sheer line.

It would be better still for the student to collect a book of his favourite drawings, and so develop his own taste. And there are innumerable superb examples of the work of Edwin Abbey, Howard Pyle, Dana Gibson, and others in the American magazines, which are better than much schooling. At foreign booksellers' may be procured for a few pence the work of Frenchmen like Steinlen, and of Germans and other foreign artists in papers like *Jugend* and *Simplicissimus*, which are not only a joy to possess, but which are also a rare education in drawing. A very useful thing, until the student can afford the schools, is to get photographs of horses, dogs, animals, or people, whether in magazines or otherwise, and try to draw them in freehand.

Modelling. Also, from the beginning, whilst the student is still giving all his strength to the mastery of drawing, he should try to sweep in broadly the modelling of the masses, not going into the details as in the old academic methods, but still getting the larger values of light and shade true, also the various values of edges—sharp or soft. Thus, when he acquires correctness in drawing, he will be able to model in the detail with ease.

The Human Form. We now come to drawing from the human form. A certain amount of anatomy may be learnt from books on this subject, but the best way to learn it is to take the male figure and the female, and to *draw* them into your knowledge. Mere reading of books on anatomy is sheer waste of time. The chief muscles and the bones should be *drawn*, so as to give the hand the knowledge as well as the head. The student will find that when he has drawn a head he is inclined, as he goes on drawing the figure, to elongate each part more and more out of all proportion to the head. Some students are inclined to do the opposite and shorten the proportions—a very ugly fault.

It is best, in drawing from life, to tick off the proportions, so as not to let the pencil stray, as it is inclined to do, into elongation. The figure roughly divides into two at the top of the legs, and artists make the head the standard of measurement, always speaking of the figure or parts of the figure as so many "heads." The height of the head goes into the upright

A CHALK STUDY BY LORD LEIGHTON
From a photograph by F. Hollyer

figure seven and a half times (the Greeks made it eight, as we shall see). The first head is, of course, to the chin, the second head comes to the nipples of the breasts, the third head to the navel, and she fourth head to the top of the legs. This is the half figure, or the whole of the head and trunk.

The fifth head comes down the thigh so far as to allow the knee to come midway between it and the next head, the sixth, while the seventh head reaches to the ankle. The foot, then, is midway in the eighth head, as the knee was midway in the sixth.

A Permissible Exaggeration. The Greeks made the shin longer, so that the foot came to the eighth head, and the figure acquired an

ONE OF RANDOLPH CALDECOTT'S ILLUSTRATIONS IN "JOHN GILPIN"
Reproduced by permission of Messrs. F. Warne & Company

added grace and dignity due to the length from the knee to the heel. It is a very permissible exaggeration, often employed with fine effect by men like Leighton.

The length of the figure kept within check, the student is not liable to go very far wrong with its breadth, but it is well to have a rough rule of thumb for the face and head also. The face is halved across the eyes; the nostrils form the quarter line (or half the lower half). The hair, roughly speaking, forms the upper quarter (or half of the upper half). The ears should, in the full face, therefore, come between the cross-line of the eyes and the cross-line of the nostrils. The width of the face is roughly twice the length of the nose, or twice the length from the nose to the chin.

It is well constantly to draw the male and female figure from memory—back, front, and side view—until the proportions are so set in the memory as to become fixed; in fact, the student should be able to draw them almost with his eyes shut. It is astonishing how accurate the brain becomes in holding these facts when drilled to it, just as it holds pages of verse by training, stored away until called for. These six forms, three of the male and three of the female figure, are enormously valuable to the artist's memory and hand.

P. G. KONODY

AN EXAMPLE OF MR. HOWARD PYLE'S ILLUSTRATIONS

Structure of the Ear. Its Delicate Mechanism.
Functions of the Tongue and the Nose.

HEARING, TASTE, AND SMELL

HEARING

All are acquainted with the appearance and shape of the external organ which we call the ear, but few know anything of the complicated structure. We may, in a sense, be said to have six ears, three on each side, for each organ is divided into *outer*, *middle*, and *inner* ear.

The Outer Ear. The outer ear consists of the *pinna*, or ear proper, and the auditory canal leading to the middle ear. In man it is of far less use as an organ of hearing than in the lower animals, partly from the feeble power we have of moving it. There are, indeed, three muscles for the purpose, but they are so weak and so little under the control of the will as to be of little use. The outer ear is, however, an ornament when well shaped, and collects some of the waves of sound.

The small knob at the upper and back part corresponds to the tip of the ear in animals, and in some men is almost a point.

The Direction of Sound. The hearing of the ear can be improved and more sound-waves collected by placing the hand behind the ear so as to enlarge it. Perhaps the chief use of the outer ear, as its general inclination is forward, is to indicate the direction from which the sound proceeds, as this is loudest when the ear is at right angles to it. The knowledge of sound direction is, however, very imperfect in many, for if a person be blindfolded it is almost impossible for him to indicate whence any sound proceeds. In almost every detail of the sense of hearing we are very deficient compared with other animals.

The Auditory Canal. The pinna leads into the *auditory canal*, an inch long, lined with stiff hairs and a bitter wax, to prevent the intrusion of unwelcome insects, and bounded at the end by the drumhead, or *tympanum*, stretched across it at an angle of about forty-five degrees. This membrane is the thickness of a piece of foreign note-paper, which will explain how easily it is injured by a hairpin or pencil. It will also be understood that all ear-drops are completely useless for any disease that lies behind this membrane, beyond which they cannot penetrate. It is unevenly stretched so as to take up vibrations of air from 30 a second to 4000. The head of a drum is evenly stretched, and can only take up one set of air-waves.

The Middle Ear. Passing behind to the middle ear, we find it is half an inch high and one-eighth of an inch broad, something the shape of a button on its end. It is lined everywhere with ciliated (wavy) epithelium, and is in direct communication with the air by the *Eustachian tube*, two inches long, opening into the throat. Air is thus freely admitted in health to both sides of the ear-drum, and in consequence it can vibrate freely. The failure of this through the stopping up of the Eustachian tube is a great and common cause of deafness. By holding the breath, and then swallowing, air can be forced up the Eustachian tube, causing a pressure that can be felt in these middle ears.

The outer wall of this chamber is, of course, formed by the *drum*, while in the inner wall opposite are seen *two smaller drums* stretched across two openings, the one being oval (Latin, *Fenestra ovalis*) and the other round (Latin, *Fenestra rotunda*).

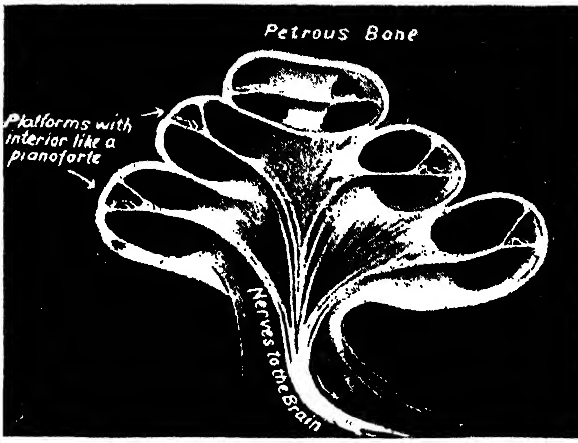
The *ciliated epithelium* always waves in the direction of the throat, so as to hinder impurities from collecting in this chamber.

Its Bones and Muscles. Stretched across the ear from the tympanum to the oval inner drum is a curious chain of three bones, the ossicles. They are called respectively, from their suggestive shapes, the *hammer*, the *anvil*, and the *stirrup-bone*. The hammer (Latin, *malleus*), slung from the roof, has its handle tightly bound down to the inner side of the tympanum, while the head rests on the head of the next bone, the anvil (Latin, *incus*). This, also slung from the roof, is articulated by one of its feet with the head of a well-shaped bony stirrup (Latin, *stapedius*), which in its turn has its base or foot-plate attached to the oval membrane on the internal wall. The purpose, if not the peculiar shapes, of these bones is sufficiently obvious. It is well known that all sounds are caused by vibrations, or waves, of air; these waves are collected by the outer ear, pass up the auditory canal, and, striking on the tympanum, cause it to vibrate. The vibrations move the air in the middle ear in a similar way, causing vibrations that strike on the membranes of the inner wall, so that some hearing is possible without the ossicles at all. The excessive accuracy necessary, however, to secure the hearing of speech is secured by this apparatus, every vibration being carried with absolute exactitude from the handle of the hammer, fixed against the tympanum by the plate of the stirrup, to the inner membrane. The speed of the vibrations is from 16 for the lowest note to 40,000 per second for the highest. Two muscles, one the smallest in the body, regulate these vibrations by tightening the drums. One of the two little muscles can both tighten the drum to a further pitch of acuteness in listening intently, or slacken it considerably if any loud sound is expected that might rupture it. The outer muscle is fixed in the same way to the stirrup to regulate the inner membrane.

The Inner Ear. In now proceeding to describe the internal ear [92], or real organ

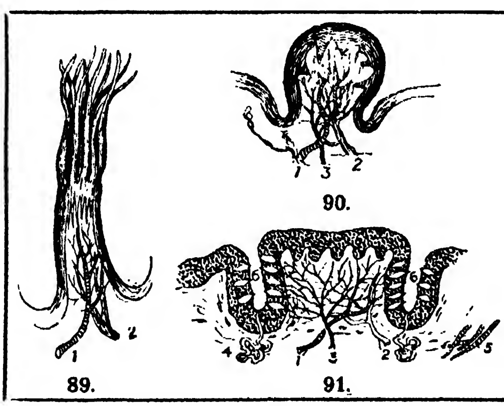
of hearing, the very simplest explanation will be given, but at the same time the details are so complicated as to need close attention, and yet they are too important to be omitted.

Behind the oval drum or *fenestra ovalis*, to which the foot of the stirrup is fixed, is a small bony chamber called the *vestibule*, filled with fluid and containing a membranous bag, also filled with fluid. This bag contains some of the naked axis cylinder endings of the *auditory nerve*, terminating in tiny, bead-like heads, and in the bag are also a number of *sharp crystals*, which, being violently moved about during vibrations transmitted from the oval drum, probably strike these nerve ends with varying force.



88. SECTION THROUGH THE COCHLEA OF THE EAR

Where Sounds are Interpreted. In the vestibule by means of these crystals the intensity and distance of the sound is judged before the waves pass on to the true inner ear to be interpreted into notes or speech. The differing intensity with which these particles strike the naked nerves is supposed to tell whether the voice or music is loud or soft, whether near or distant, whether advancing or receding, and so on. This vestibule also contains five openings leading to the *three semicircular canals* (two of them having a common opening), which are very curious structures, made of bone, and all opening into the vestibule, the first being *vertical* to the position of the body, the second *horizontal*, and the third *transverse*, so as to lie in the three directions of solidity—length, breadth and depth.



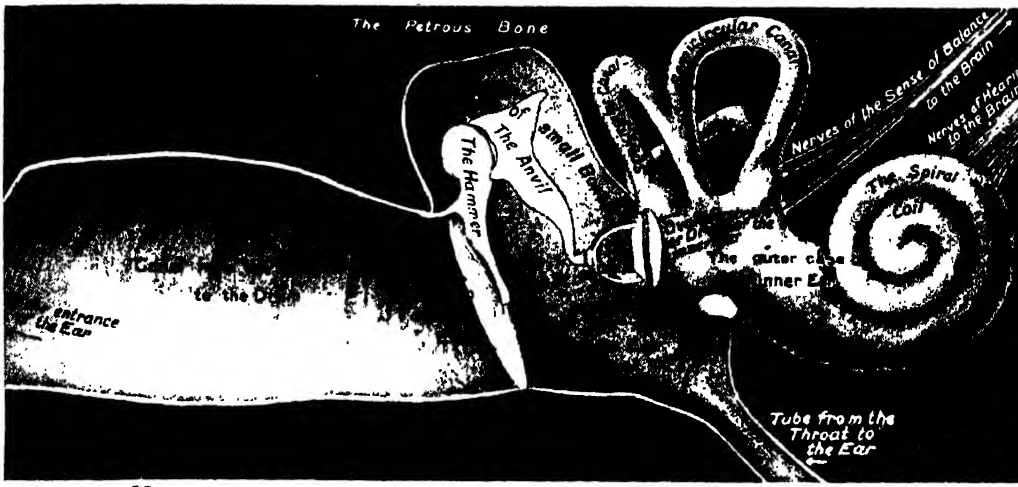
89-91. PAPILLÆ FOR RASPING, TOUCHING, AND TASTING

89. Filiform, rasping; 90, Fungiform, touching; and 91. Circumvallate, tasting. 1, artery; 2, vein; 3, nerve; 4, water-gland; 5, muscle; 6, taste-ends at sides of trench.

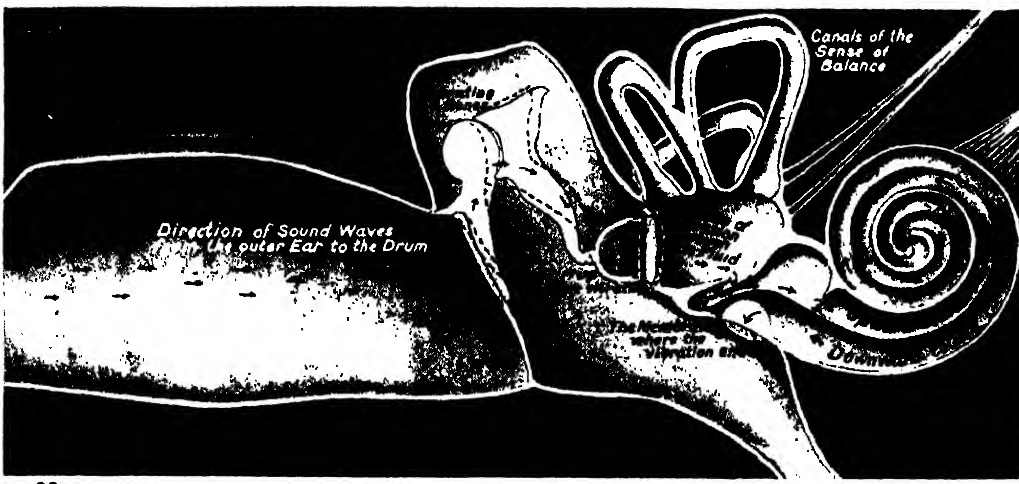
Human Spirit-levels. The canals are also lined with membranes filled with fluid, and are supposed to act like spirit-levels; they are connected with the cerebellum, or organ of equilibrium, so that it is informed at once in which canal the greatest pressure exists, according to the varying positions of the head, and can automatically restore the balance by muscular action. It has been found that in certain diseases, when one of these canals has been injured, the body has the tendency to roll over in a similar direction, either forward, or sideways, or backwards. The canals are also supposed to determine the position of the sound we hear.

Delicate Mechanism. Leaning against the internal wall of the vestibule and also against the round drum of the middle ear is the broad end of what looks like a small periwinkle shell, *the cochlea* [88], which, instead of having one spiral canal, has two, the one (the *scala vestibuli*) opening into the vestibule, the other (the *scala tympani*) ending at the round opening in the middle ear. This double canal consists of two and a half turns, getting, of course, smaller towards the top, where the two communicate by a minute hole. Both are entirely filled with a limpid saltish fluid. This double spiral is separated by a fine membrane (the *basilar membrane*). The upper spiral of the *scala vestibuli* is subdivided again by the *membrane of Reissner*, and the lower space is called the *scala media*. In this scala media is the *organ of Corti*, or the real apparatus for hearing. Resting on the inner and upper surface of the basilar membrane, and continuing round and round to the top, are a continuous row of *little headed rods*, like pianoforte hammers, all graduated in size, getting smaller and smaller as they ascend, about 6000 in number [94]. On the outer side of the membrane are arranged a corresponding number of *hollow pads*, into two of which three of these little hammers accurately fit, there being therefore about 4500 of them, and it must clearly be remembered that every hammer and every pad is a living cell. These hammers and pads form a tiny spiral arch, decreasing in size all the way up. There are also two or three rows of stiff, bristle-like cells along this canal, passing through holes like eyelet-holes in the membrane above, in which they can freely vibrate.

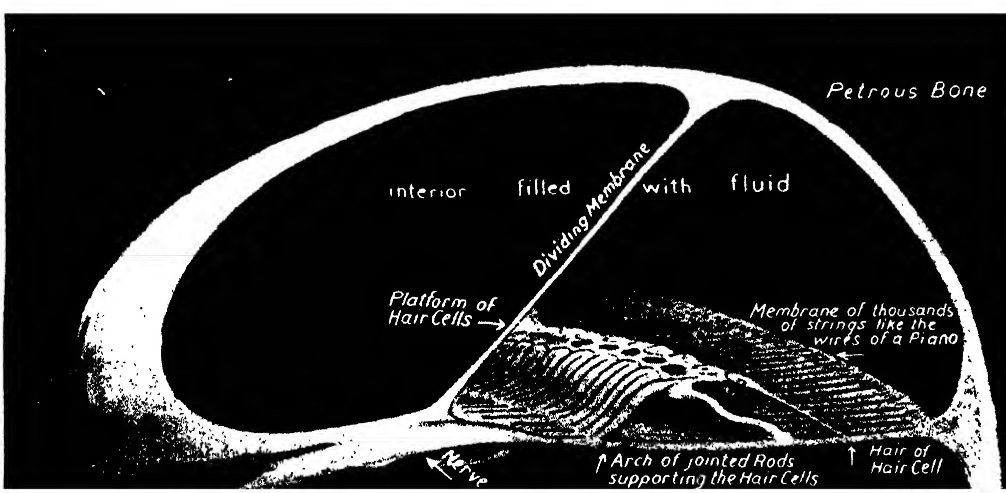
THE WONDERFUL MECHANISM OF THE EAR



92. THE CHAMBERS AND BONES OF THE OUTER, MIDDLE, AND INNER EAR

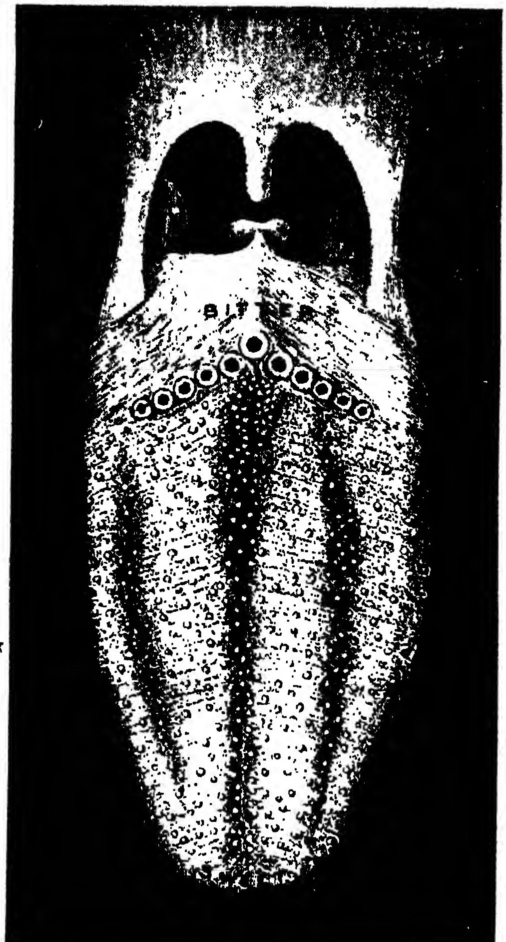


93. DIAGRAM SHOWING HOW A SOUND-WAVE PASSES THROUGH THE EAR TO THE AUDITORY NERVES



94. A SECTION OF THE COCHLEA, SHOWING THE LITTLE HEADED RODS AND HAIR-CELLS

How Sound is Transmitted. All this is supposed to be an arrangement for receiving and interpreting in some way the vibrations in the fluid around received from the air-waves of sound by the two drums of the outer and middle ears, and transmitting them through the two divisions of the scala vestibuli up to the top of the spiral, whence they return



95. THE TONGUE, SHOWING AREAS OF TASTE
Most of the distinct types of taste buds that appreciate the sweet, the acid, and the bitter are found in the areas marked.

down the scala tympani to the round drum [93]. There are three theories as to how sound is transmitted as vibrations to the auditory nerve. It is supposed that each hammer vibrates to a definite length of vibration, and thus interprets the sound. A second theory is that it is the stiff bristle nerves that are thus tuned to take up the vibrations; but attention has lately been drawn to the structure of the basilar membrane itself, on which these both rest, and which is believed to consist of an infinite number of strings of different lengths, stretched side by side all the way up, and able, like violin strings, to respond to different vibrations; and the third theory is that this membrane is the true organ of hearing, the hammers, etc., resting on it serving merely to "stop" or deaden the strings. It is still a moot point as to whether the hammers, bristles, or membrane are the true organ of hearing. All three, however, are directly connected with the auditory nerves that run up the central pillar round which the spirals turn and transmit all vibrations to the auditory centre in the brain.

Just as in the eye, if the centre of hearing in the brain be injured all the elaborate apparatus we have described is useless. The ear has been compared to a telephone, as both depend entirely in the same way on vibrations.

Sound-waves Heard and not Heard. The waves of sound are waves in the air, very like waves at sea, varying from the lowest note we can hear, which are waves 64 ft. long, and 16 to the second, to the highest, which are waves one-third of an inch long and 38,000 to the second, each octave higher having waves twice as fast and half as long as the fundamental note. There are plenty of sounds too shrill for our ears to receive—the squeal of a bat, the chirp of a cricket, are thus often unheard by us. By the aid of a Galton's whistle, notes can be produced too shrill for the human ear, though they can be easily heard by a horse or a dog.

Noises and Notes. The difference between a noise and a musical sound or note is that in the latter the waves are regular and of uniform length; in the former they are a mixture of different lengths.

From this brief description of hearing, it will be noted that the sound-waves are transmitted by three media--solids, liquids, and gases. In the outer ear the waves are conducted partly by the air and partly by the cartilages of the ear and the bones of the head. The chain of bones transmits them to the inner ear, whence every vibration is taken up finally by fluid which, striking in various ways on the bare terminations of the auditory nerve, cause the perception of sound in the brain.

TASTE

Pimples on the Tongue. The tongue, the organ of taste, is covered with three varieties of papillæ or pimples. The first, called *filiform papillæ* [89], are thread-like elevations that abound over the middle of the tongue. They are sharp, whitish, and pointed. In a cat they are very hard, like small thorns or spines, while in the lion or tiger they are of terrible size, like rows of teeth, and capable of stripping the flesh off a bone with a single lick of the tongue. They are principally used in man for rasping the food against the furrowed roof of the hard palate.

The second class of pimples on the tongue, called *fungiform papillæ* [90], are mushroom-like elevations; these are scattered all over the tongue, and especially towards the front. They are round and very red, and the skin over them is very thin. They contain touch corpuscles, and are really a delicate part of the

great sense of touch. They can at once discern the quality of what is in the mouth, and if it be too hot or cold.

The third class of pimples are much larger, and form a striking object at the back of the tongue. These are the *circumvallate papillæ* [91 and 95], or the "circular trench" pimples. They owe their peculiar name to their extraordinary shape. They are arranged—ten or twelve in number—right across the back of the tongue in the form of a V, with the point backwards, so as to catch all the food as it passes into the pharynx before it is swallowed. Each one consists of a flattened elevation with a slight central depression, and is surrounded by a depression like a trench (hence the name), and beyond the ditch is a slight circular elevation like a wall. Opening into the bottom of this trench are the numerous orifices of the glands which secrete a very powerful juice of great solvent power, while all along the sides, embedded in the walls, are bodies like oranges, called *taste buds*. From the top of each of these oval bodies, projecting into the trench, is a circular row of stiff hairs, making the whole rather like the head of a thistle. Part of all the food that is eaten falls into the trenches of these papillæ and part is dissolved; and then it is supposed that the ultimate particles strike against the hairs, which are really naked "nerve endings," but look like the feelers of sea anemones. The vibrations are conveyed to the taste buds and thence to the taste centre in the brain.

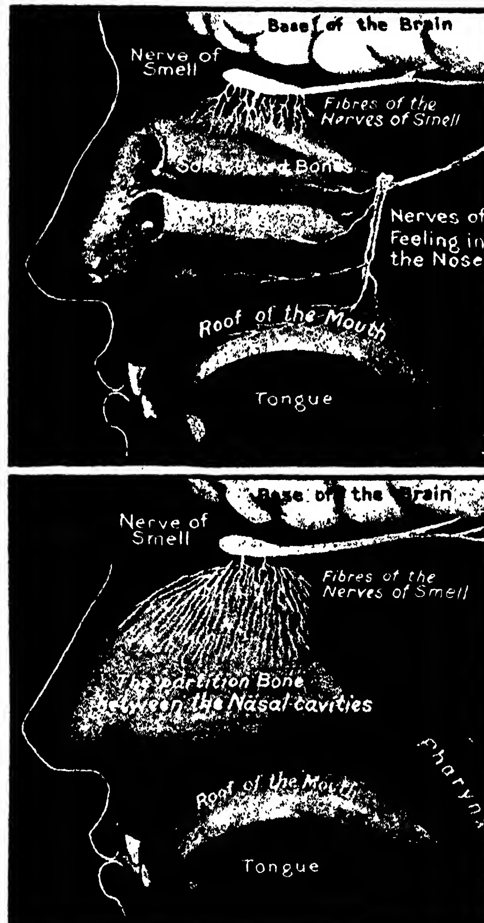
How we Taste. In speaking of all these organs of special sense—whether of touch, taste, smell, hearing, or sight—it must be remembered that the special apparatus we described is only an arrangement for accurately transmitting the peculiar vibrations or sensations to the brain, which alone feels, tastes, smells, hears, or sees. Consider for one moment the marvels of a "special sense." The salt-cellar, for instance, has been filled up in mistake with sifted sugar, and you eat it with your beef. You believe it is salt, and expect to discern its taste on the meat in the mouth. Some minute portions dissolved in the trench strike against the projecting nerve ends, and in some inscrutable way send up vibrations to the brain quite different from salt; and so strong is the effect in the taste centre that, against your belief, you declare it is sugar.

SMELL

The sense of smell really resides in the upper part of the nose, and here the olfactory or smelling nerves are situated. They project downwards in innumerable fine, hair-like endings into the upper part of the nostrils, and are connected above with two large bulbs of brain matter in the under surface of the cortex of each hemisphere.

All parts of the nose can *feel* acutely; but if we wish to *smell* anything, we sniff up the odour into the upper part of the *nares*, or nostrils [96.]

How we Smell. *Odours* are either suspended in exceedingly fine particles in the air or in gases so thin and imperceptible that it is only by the sense of smell they are discovered. The odour must be dissolved in the secretions of the nose before it can be smelled. Hence, with both taste and smell, if the article be absolutely insoluble, it cannot be discerned. If the nose be dry, as in fever, the sense of smell is lost; or, if there be too much secretion, as in a heavy cold, it is much impaired. The use of the sense of smell is a good deal under our own control, for it requires an effort of the will to hold the breath and take a deliberate sniff. This sense is far less keen in us than in animals.



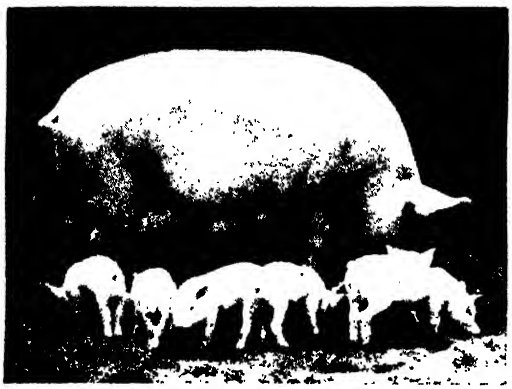
96. THE OUTER AND INNER PARTS OF THE NOSE
Showing the nerves fibres from the olfactory bulb, and the nerves of smell and feeling.

Flavours. Some smells, such as those of pepper, ammonia, and acids, can hardly be distinguished from common sensation; and others, closely connected with tastes, we call flavours. The delicacy of the olfactory sense is most remarkable, for the most minute traces (one thirty-millionth of a gramme of musk), quite impossible to discern by any other means, can be smelled. Pleasant and unpleasant odours are merely questions of judgment, just like colours and sounds; and what constitutes the sensation of pain or pleasure to which they give rise is not fully understood. A. T. SCHOFIELD

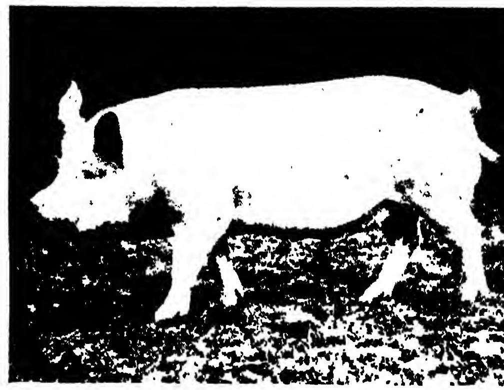
TYPICAL EXAMPLES OF BRITISH PIGS

MIDDLE WHITE SOW

MIDDLE WHITE BOAR



LARGE WHITE SOW



YOUNG LARGE WHITE SOW

BERKSHIRE BOAR

TAMWORTH BOAR

LARGE BLACK SOW

SMALL WHITE BOAR

The four upper photographs are reproduced by courtesy of Messrs. Chivers & Sons, Histon

The Best Pigs for Bacon. Selection of Stock. Feeding and Housing. Care of Young Pigs.

PIGS AND PIG-BREEDING

Pigs are found on most farms in the United Kingdom. They are particularly valuable for utilising with profit the waste products of the dairy, field, and garden. When refuse of this sort is available, or scraps from the house and kitchen are forthcoming, a pig can be economically fattened, either for market or home consumption, with a very small addition of purchased food in the form of meal. Again, as a meat producer, in proportion to the amount of food consumed, the hog—with the exception of the milk-fed calf—far surpasses all other domesticated animals.

In fact, the pig has been called "the most economical meat-making machine in the hands of the British farmer." And this is all the more evident when it is remembered that one hundredweight of digestible food will produce at least twice as much pork as it will beef or mutton.

The original type of pig found in Great Britain was a huge, gaunt, roach-backed, long-legged, slow-growing brute much resembling its ancestor the wild boar, and the gradual development to the neat, compact, flesh-producing animal of to-day has necessarily been slow. The present breeds of swine of the United Kingdom have been improved chiefly by crosses made with foreign and native breeds, and by greater care being exercised in the methods of management and feeding. This crossing with foreign breeds, especially the Chinese pig (*Sus indicus*), was principally carried out during the first half of the nineteenth century.

As is well known, certain parts of the carcase of a pig are more valuable for purposes of sale than others. It should, therefore, be the breeder's object to raise an animal that has these parts best developed.

An Excellent Pig for Bacon. The type of pig now required for purposes of feeding for bacon and in demand by the bacon-curer may be described as follows: The head and neck should be light and the shoulder free from coarseness, as these parts do not command so high a price. The body should be long and deep, with well-sprung ribs, giving a wide back and loin capable of being well packed with flesh, as here the valuable cuts are situated, and a good side of bacon is a primary object. The thighs should be thick, the legs short, and the hair long and silky.

Sufficient depth in the region of the heart is also desirable, as it shows a good constitution. Further, the bone below the knee and hock (cannon) should be fine, as this indicates lightness of offal and a tendency to the development of lean meat.

Principal Breeds of Pigs. In selecting a breed of pigs for any particular district the question of colour must be taken into consideration, as, owing to local prejudice, white pigs are favoured in some markets, and black in others. If a farmer, therefore, breeds pigs of a colour not in fashion in his neighbourhood, he may suffer considerably as regards the price obtained should he wish to sell in the local market. The colour, however, has nothing whatever to do with the thriving properties of the animal.

Large White Yorkshire. Among the white breeds of pigs the large white Yorkshire is one of the best, and is particularly well suited to the requirements of the farmer, and highly prized by bacon-curers. It is large in size without being coarse, the proportion of offal produced is small, and the meat is sufficiently lean for modern requirements. It is handsome and symmetrical in appearance, comes early to maturity, is very prolific, and may be used for purposes of either pork or bacon. It is hardy, of a good disposition, and the sow is an excellent mother.

The colour should be white and free from black hairs; the head moderately long and wide between the ears; and the body should be long, level, wide and deep, with broad loin and well-developed hams.

Middle White Yorkshire. This breed, which originated by a cross between the small and large white, takes after the latter in appearance, but is not so long, and the body is rather more compact. The head also is shorter, the face more dished, and the snout somewhat turned up; the ears are more upright, the legs shorter, and there is a greater abundance of fine, soft hair. Further, these pigs do not produce such a good proportion of lean meat as the large white, and are, therefore, not so profitable to the farmer as bacon producers. In these circumstances they are rather better suited for the production of pork than bacon, and consequently there is a demand for middle white boars for crossing purposes by breeders who aim at producing pork.

Small White Berkshire. These pigs are now very little bred in the United Kingdom, except in a few special cases where a market exists for small pork. For their symmetry of form, quick-feeding properties, and smallness of offal they may be taken as an excellent example of the skill of the breeder. They are somewhat delicate in constitution, and care has to be exercised in feeding, as they tend to lay on excessive quantities of fat in proportion to lean meat, appearing at some of the fat-stock shows as mere balls of lard. They cannot, therefore, be looked on as a farmer's pig for general utility purposes.

The special characters are a pure white colour, head very short and dished, with broad and turned-up snout and heavy jowl; ears pricked, and body broad, deep, and compact.

Lincolnshire Curly-coated. This is a large sized, white-coloured local breed from the east coast of Lincolnshire. The face is shorter than that of the large Yorkshire, and there is an abundance of long curly hair when the coat is fully grown. The ears are pendent and not pricked like those of the Yorkshire. It is claimed for the breed that it is hardy, prolific, and of good disposition, and feeds quickly, producing equally good pork and bacon.

Berkshire. Among coloured breeds the Berkshire is one of the best known, and very popular in England and abroad. Owing to the care bestowed upon it by the early breeders and its many excellent qualities, it was at one time considered the most important of the pure breeds, and was much used for crossing purposes. During recent years, however, the tendency has been to breed more on fashionable than utility lines.

The colour is black with a white blaze on the face, white feet, and white tip to the tail. The head is neat with erect ears, and the object now is to get the face as short and well dished as possible. The body should be broad and straight, and should possess a wide, level back.

Large Blacks. These pigs have been bred for a good many years in different parts of England. The outcome of the formation of the Large Black Pig Society at the end of the nineteenth century has resulted in the development of a bacon pig on similar lines to the large white, and killing to about eight scores dead weight when about seven to eight months old. It also has a quiet disposition, good constitution, feeds quickly, and is very prolific. It is black in colour, with a head of medium length and long, thin ears hanging well over the face. The body is long and level, well sprung in the rib, and able to produce a good side of bacon.

Tamworth. This is of a reddish, or rusty, colour, and probably the oldest breed of pigs in England. It is hardy and prolific, and much in colour for purposes of home curing, as it yields a large side of lean bacon of excellent quality and flavour. The head is of a fair length, and the snout is long and straight, being quite in contrast to that of the small white or the modern type of Berkshire. The ears are rather large and erect, and carried slightly forward. The body is long and straight, the girth deep, and the loin wide. The skin is of a flesh colour, and covered with an abundance of long, straight, fine hair of a golden red, which gives the characteristic colour to the pig.

The principal objection to the Tamworth in the past has been its slowness in coming to maturity, but this fault is being remedied by care and selection.

Cross-bred Pigs. For ordinary feeding purposes a first cross between two pure breeds often produces a pig better adapted to provide a good carcase of bacon than the pure breeds themselves. When crossing, consideration must be taken as to the points of the respective breeds, and it is not wise as a rule to go beyond a first cross. The following crosses may be recommended as yielding first-rate types of bacon pigs: (*a*) large Yorkshire boar and Berkshire sows; (*b*) large black boar and Berkshire sows. The first of these crosses is particularly favoured by bacon curers.

General Management of Pigs. In starting to breed pigs great care must be taken in the selection of the breeding stock. A number of points should also be considered before determining upon the choice of variety. Thus, the kind of pigs generally kept in the district should be noted, and a study made of the requirements of the local market before a decision is finally come to. It is further necessary to have some ideal as to the type of pigs one wishes to breed, and to select the boar and sows accordingly.

The Choice of a Pig. It is best to choose a boar, if possible, from a good mother of prolific strain, and he should have an even temper and quiet disposition. Well-developed teats in the male are a good sign. The young boar may be used when six to eight months old, and it is wise to mate him at first with fully grown sows. He should be kept in ordinary store condition, and not be pampered. He must have plenty of exercise, and, treated with care, he ought to prove useful and last for a number of years.

His food should consist principally of sharps, or coarse bran mixed with barley meal, fed to him in two meals daily. A little corn in the shape of old peas, beans, or oats is useful and may be given as a midday feed.

Young sows should be chosen with good points, according to the variety, a quiet disposition, and not less than twelve evenly placed teats. Gilts may be put to the boar at from six to eight months old or upwards. The period of gestation is 113 days, or sixteen weeks. Sows, therefore, if mated in October or April will farrow in February or August, the latter being generally considered good months for producing spring and autumn litters respectively. Seven or eight pigs may be looked on as a sufficient number for a gilt to rear in her first litter, but the more pigs brought up under favourable conditions the better, as in the second litter those pigs which suck teats that have been used by the first litter obtain more milk and thrive better than others. A gilt's capabilities may be judged by the way she rears and suckles her first litter, and the opinion thus formed will show whether she should be bred from again or sent to the fattening-pen.

A good disposition is a matter of great importance in a sow, as occasionally well-bred gilts of handsome appearance may be purchased which develop savage instincts when they come to farrow—not only objecting to the attendant who is watching their interests, but sometimes going so far as to destroy their own offspring. Some knowledge, therefore, of the mother and other ancestors of any young sow—especially as regards temper—will be a great advantage before effecting the purchase.

Some care is necessary in feeding the sow for the first few weeks after farrowing, and nothing is better for this purpose, if available, than well-soaked bran or sharps mixed with a little skim milk or buttermilk. If everything goes on satisfactorily, a small quantity of meal may be gradually added to the ration so as to assist the sow in producing an abundant flow of milk. The young pigs should be weaned at eight weeks old, the process being performed between the seventh and eighth week.

Feeding and Housing. A very common and erroneous idea often prevalent in the rural mind is that a pig can be kept and expected to thrive under the most unwholesome and insanitary conditions. They are therefore allowed to wallow in a filthy sty on a rotten accumulation of litter, which is seldom removed until the unfortunate pig has found its way to the butcher. The feeding is also performed in a haphazard and slovenly manner, accumulations of garbage being allowed to remain in the trough from one feeding-time to another. There can be no greater fallacy, and no wonder, under such condi-

tions, that pigs are often considered not only as unprofitable but as an intolerable nuisance.

Pigs, if given the opportunity, however, will be found most respectable animals, showing great intelligence in keeping themselves clean and attending to their personal comfort. Thus, if housed in a sty with an inner and outer court, they will be found to keep their bed in the inner covered part clean, dry, and comfortable, and will deposit their excrement in a corner of the open yard. Sties should, therefore, be provided with hard floors, such as cement concrete, set with a proper slope so as to allow for surface drainage, as sties of this description can be kept clean by brushing. A sufficient supply of clean, sweet straw should also be available for the pig's bed in the inner court, and this should be changed periodically as soon as it becomes soiled.

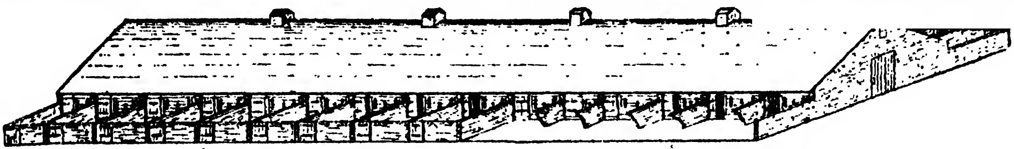
The feeding of these animals must be carried out in a cleanly and methodical manner, no more food being put in the trough at one time than the occupants of the sty will clear up before the next meal. Under these conditions, which necessitate little extra labour when systematically carried out, pigs will be found to be healthier, to thrive and grow better, and make a much larger return for the quantity of food given than when kept in an insanitary state.

The Type of Pig in Demand. As in the case of beef and mutton, the public taste for pork has considerably altered. What is now required is a young carcase of sweet flesh suitable for consumption as fresh pork, or capable of being turned into sides of lean, mild-cured bacon. In these circumsances the old custom of feeding pigs up to two years old or more, and killing so as to produce huge carcases, largely of fat, has almost entirely died out.

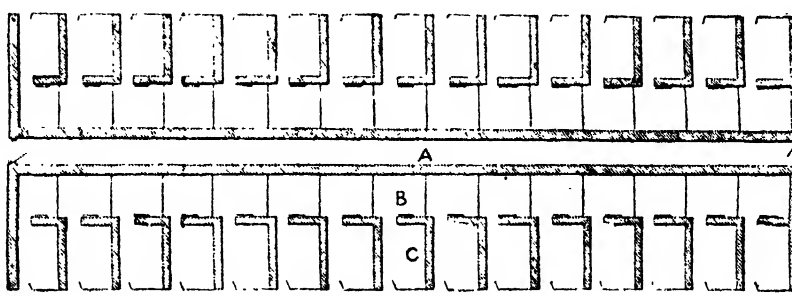
The type of pig at present in most demand is one which will fatten quickly, and be ready for the butcher at some seven or eight months old, when it should yield a carcase of from 160 to 170 lb. in weight. This is the kind of animal now sought after by the bacon-curer, and to produce pigs of this stamp it is necessary to keep the animals going steadily on without a check from the time of weaning till they are fit to go out. The young pigs should, therefore, be run as rapidly growing stores till they are about five months old, and then be quickly finished off on a more concentrated ration, consisting largely of barley meal, in from eight to twelve weeks.

Feeding Young Pigs. Two great points to pay attention to in the successful feeding of young pigs are cleanliness and warmth, and these factors are quite as important as the question of food. As the little pigs' stomachs are small, they should be fed four times a day immediately after weaning, and as they get stronger this may be reduced to three times daily. On no account must they be over-fed at first, and a mixture of bran and sharps, with a little skim milk or wash, will be found a suitable diet. Care must be taken to avoid giving foods which have decidedly heating properties, such as wheat-meal and pea-meal, in any quantities to young pigs during the early stages of their existence; but meal may be gradually introduced, and increased by degrees as the fattening period advances.

Experiment has clearly shown that as the weight of a pig advances, so does the amount of food required to produce a given increase; so the sooner a pig is fattened off the better prospect there is of leaving a margin of profit for the feeder. In the case of the cottager's pig, the object is not only to produce a wholesome carcase of meat for home consumption or sale, but also to turn to profitable account a lot of waste material from the garden and allotment, together with wash or scraps from the kitchen, and at the same time to produce a quantity of valuable manure for subsequent use. In these circumstances feeding to somewhat heavier weights till from twelve to fourteen months old often suits his purpose better.



LORD MORETON'S PIGGERY AT TORTWORTH COURT
Height from floor to ridge, 14 ft. 6 in. Width (interior), 27 ft.: including yards, 49 ft. 10 in.



GROUND PLAN
A. Central passage, 149½ ft. long by 5 ft. wide. B. Sties. C. Outer yards.

The Pig Trade. As to statistics, the pig trade is a fluctuating one, the total number of animals in the United Kingdom rising and falling every few years, and never exceeding some 4,500,000. The reason of this seems to be due to the fact that when good prices are obtainable in the home markets everyone starts breeding, the price goes down, and many of the breeding sows are then disposed of.

On the other hand, we find that pig products to the value of some £20,000,000 sterling are imported annually into the United Kingdom, which roughly represents 5,000,000 pigs per annum.

The question of whether a part of this great quantity of bacon could not be grown profitably at home turns on the possibility of running factories on sound business principles in various parts of the country. Private bacon factories yield large profits, and there seems no reason why these should not be established by farmers themselves, and conducted on co-operative lines with every prospect of success.

DRYSDALE TURNER

Some Important Oxides and Sulphides. Nitrous, Nitric, Sulphurous, and Sulphuric Acids. Sulphates and Amides. Alloys and Amalgams.

SOME INORGANIC COMPOUNDS

Before going on to discuss the basic chemical laws, and the way in which they have been affected by modern physical theories of matter, it is necessary to deal with certain compounds—oxides and sulphides—which have not come into the general sequence. The normal oxide of hydrogen having already been discussed under the name of water, we may add a few words regarding the peroxide of hydrogen (H_2O_2), mentioned on page 693. This characteristic oxidising agent is a heavy, syrupy liquid, colourless, and with a distinctive taste. It is nearly half as heavy again as water.

Sulphuretted Hydrogen. The most important sulphide of hydrogen has the formula H_2S, corresponding to water (H_2O)—we have already seen that oxygen and sulphur should be classed together—and is a colourless gas, with the characteristic odour of rotten eggs, which owe their odour to the production of this gas from the sulphur contained in white of egg. The gas may, of course, be liquefied and frozen. It is found in the gases produced by volcanoes, and in the water of many medicinal springs, such as those of Harrogate. If breathed, sulphuretted hydrogen is poisonous, and, as might be expected, it is combustible, forming water if there be but a limited supply of oxygen, while the sulphur is precipitated, but forming both water and sulphur dioxide (SO_2) if the supply of oxygen be abundant. The commonest way of producing sulphuretted hydrogen is by the decomposition of a sulphide, especially ferrous sulphide (FeS), by means of sulphuric acid. When we observe the formula of any sulphide, such as FeS, we see again the parallelism between oxides and sulphides. Among the other simple sulphides and oxides which are worthy of special mention there are many that have already been sufficiently dealt with. The following have not.

Bisulphide of Carbon. Carbon bisulphide, or bisulphide of carbon (CS_2), is formed by the direct union of carbon and sulphur, and is thus strictly comparable with carbon dioxide (CO_2). This, however, is a colourless liquid, which is heavier than water, and almost insoluble in it, while it gives off an inflammable vapour. The products of its combustion are naturally carbon dioxide (CO_2) and sulphur dioxide (SO_2). Bisulphide of carbon is used in the manufacture of a large number of indiarubber goods which require to be vulcanised so that they may withstand changes of temperature. The process is very often performed by using sulphur chloride in solution in bisulphide of carbon. Unfortunately, the continued inhalation of this substance causes very serious symptoms in the worker in many cases.

Nitric Acid. We must now pass to consider an acid which ranks in importance with hydrochloric acid, already described, and sulphuric acid, to which we shall soon come. This is nitric acid, which has the formula HNO_3. When discussing the law of multiple proportions, on page 695, we mentioned five kinds of molecules compounded of nitrogen and oxygen. Nitric acid is to be regarded as the acid formed by the union of water and the pentoxide, as it is called—from Greek *penta*, five—of nitrogen (N_2O_5). Nitric acid, with its powerful action upon almost all substances, does not occur as such in nature, and is usually obtained by turning it out from one of its salts, called nitrates, by means of sulphuric acid. The following is the equation, which the reader will recognise as being exactly comparable to the equation we have already given for the production of hydrochloric acid from sodium chloride:

$$NaNO_3 + H_2SO_4 = NaHSO_4 + HNO_3.$$

We see that the products of the decomposition are the acid required and the same salt, acid sodium sulphate, as was formed in the previous instance. Sulphuric acid is less volatile than either of these other acids, and thus will turn them out of their compounds on heating the mixture, not because it is more powerful, but because the nitric acid is driven off by heat before the sulphuric acid. Nitric acid is a powerful oxidising agent, and has very marked actions upon the human body; it stains the skin yellow. Its anhydride, as we have seen, has the formula N_2O_5, and is a white crystalline body which forms nitric acid when added to water. The reader will be able to write for himself an equation that represents the change.

Laughing Gas. The peroxide of nitrogen (NO_2) is a reddish gas which probably has the formula stated at high temperatures, but the formula N_2O_4 at lower temperatures, as if the effect of the higher temperature were to split into two the larger molecules which occur when the gas is frozen. This gas cannot be breathed. On the other hand, nitrous oxide, having the formula N_2O, is a colourless gas, with a not unpleasant sweetish taste and odour, which can be readily breathed, and is familiar as laughing gas. It may be made in various ways, the simplest of which is heating ammonium nitrate, which is decomposed, yielding nitrous oxide and water, according to the equation:

$$NH_4NO_3 = 2H_2O + N_2O.$$

This gas can be readily liquefied, and is sold, like oxygen, in steel cylinders, for surgical purposes. It has the distinction of being, on some grounds, the oldest anæsthetic, and is very largely employed in dentistry, while it is largely coming into use in general surgery in

combination with, or preceding, other anæsthetics. The extreme safety which attends its use, and to which it owes its value, has a very interesting explanation. The essential part of the act of breathing may be simply stated as the removal of carbonic acid from the blood, and the addition of oxygen to it. Now, most anæsthetics owe their action to some chemical combination which they form with the nervous tissues, but nitrous oxide appears to have an entirely different action. When breathed in place of air—more dangerous anæsthetics being breathed in only very small proportions *in* air—nitrous oxide appears to form a temporary union with the hæmoglobin or red colouring matter of the blood, the normal business of which is to form a similar union with oxygen.

Action of Laughing Gas. Thus the nitrous oxide completely deprives the nervous tissues of that constant supply of oxygen which is necessary for consciousness. On the other hand, the gas does nothing whatever to interfere with the other half of the process of breathing—the removal of carbonic acid from the blood. In accordance with the laws of partial pressure [see PHYSICS], this process freely continues while the gas is being inhaled, and it is because the process is so extremely simple, and because the removal of the poison is not interfered with, that this gas is so extremely safe. But, of course, it cannot act for long. As soon as the mask is taken away, and the patient breathes ordinary air, the pressure of the nitrous oxide in his blood becomes far higher than the pressure of the minute quantity of nitrous oxide that may be in the atmosphere, and so the gas is rapidly exhaled, and under ordinary conditions the dentist cannot very well count on much more than a minute of anæsthesia. When the gas is breathed in marked dilution it produces much exhilaration, whence its name.

Nitrous Acid. In contrast with nitric acid (HNO_3), we must make the acquaintance of nitrous acid, which has the formula HNO_2, and the anhydride of which, nitrous anhydride, has the formula N_2O_3. This is a dark-blue liquid which is extremely unstable, and cannot exist at all in a gaseous state, but which, with ice-cold water, forms nitrous acid. The reader can easily write an equation for himself which will prove that a molecule of water and a molecule of nitrous anhydride, if combined, must yield two molecules of nitrous acid. Just as nitric acid forms nitrates, so nitrous acid forms salts, which are called nitrites.

The series of nitrites in general have a very remarkable action upon the body, an action which was first observed in the case of the organic nitrite called amyl nitrite, but is shared by such salts as sodium nitrite. The common property of all these substances, whether organic, inorganic, liquid, gaseous, or solid, is to cause immediate and marked relaxation of all kinds of involuntary muscular tissue in the body—an action not yet explained; but it is to this that they owe their remarkable and almost unique value, discovered many decades ago by Sir Lauder Brunton, in the treatment of pain of the heart, asthma, and all forms of colic.

Sulphur Dioxide. Sulphur and oxygen form two very important combinations with each other. One of these is sulphur dioxide, or sulphurous anhydride, already referred to, having the formula SO_2, while the other is sulphur trioxide or sulphuric anhydride, which has the formula SO_3. Sulphurous anhydride, together with a certain quantity of the trioxide, is formed when sulphur is burned in air, and is the agent of fumigation, or disinfection, by sulphur. It is a colourless gas, with an extremely pungent smell, much more powerful but less disagreeable than that of sulphuretted hydrogen. It is a true disinfectant, being antagonistic to all forms of life. But this is not to say that the fumigation of a sick-room by means of sulphur, as ordinarily practised, is anything but a pitiable and dangerous farce. It is one of the first axioms of natural philosophy that a thing cannot act where it is not. Readers of the course on PHYSICS will remember our difficulties in this respect in relation to the force of gravitation. Similarly, sulphur dioxide, though an excellent antiseptic, cannot act where it is not, and, as a rule, it never reaches those very places where the microbes of disease are hidden. In order to utilise properly its disinfectant powers, a room should first be practically emptied, and should then have a very large quantity of sulphur burnt in it, while all outlets for the gas are rigorously closed. This may most unpleasantly and, as a matter of fact, permanently affect the appearance of the room, but it will be effective. The kind of fumigation that does not hurt the room does not hurt the microbes.

Sulphurous Acid. We have called this gas an anhydride, and its acid, of course, must have the formula H_2SO_3, which is obviously obtained by adding together the formulas of water and sulphur dioxide. At low temperatures this acid is stable, and is thus comparable with nitrous acid. It forms sulphites, just as nitrous acid forms nitrites, a typical example being sodium sulphite, which naturally has the formula N_2SO_3. Sulphurous acid is a weak acid, and is readily turned out of its compounds by means of other acids, such as sulphuric acid or hydrochloric acid.

Sulphur Trioxide. Sulphuric anhydride, or sulphur trioxide, SO_3, occurs in two modifications at ordinary temperatures: (1) the liquid form, having molecules of the formula SO_3, while (2) the solid crystalline form has its molecules doubled, *i.e.* $(SO_3)_2$. It is less stable than sulphur dioxide, and one atom of sulphur can be persuaded, so to speak, to combine with three rather than with two atoms of oxygen only if the conditions are made specially favourable. The trioxide is decomposed into the dioxide and oxygen at the temperature at which sulphur burns, and hence only minute quantities can be produced by this means. But if a mixture of dry sulphur dioxide and oxygen be passed through a red-hot tube coated with platinum, the trioxide is formed by one of those most curious actions which resemble those of a

ferment, and are called catalytic. When we discussed platinum, we noted the singular chemical properties which it possesses, being able, for instance, to induce such chemical actions as the direct union of oxygen and hydrogen at ordinary temperatures. It was there argued that in all probability the platinum acts by breaking up a certain number of the gaseous molecules, so that the atoms thus divorced are liable to seek new partners. The formation of sulphur trioxide is another illustration of this argument.

Sulphuric Acid. We have called the trioxide an anhydride, and on combination with water it forms the very important acid known as sulphuric acid (H_2SO_4), the formula of which is obviously obtained by adding together a molecule of water and a molecule of the trioxide. Of such great importance is this acid that the amount of it that is used in any country can be employed as an index of its measure of material civilisation. At least, this is what has been more or less jokingly said, and certainly many means of judgment much less accurate are often employed. It might be thought that the easiest way to prepare sulphuric acid (which does not occur free in nature) would be to oxidise directly sulphur dioxide, meanwhile adding water to it, but owing to the cause we have already named this is not possible. The actual process of manufacture is of some complication. The essential principle is that sulphur dioxide is obtained by burning iron pyrites (FeS_2), and that by means of nitric acid fumes the dioxide is further oxidised into the trioxide, the oxides of nitrogen in the fumes acting as oxygen carriers. When the pure acid is finally obtained it is found to be a thick, colourless, heavy liquid, which has an extraordinary affinity for water, so much so that it is practically impossible to obtain sulphuric acid that is entirely free from water.

Anhydrous Sulphuric Acid. It is unsatisfactory to say, as is often said, that it is impossible to obtain "anhydrous sulphuric acid," because we might reasonably expect that term to indicate sulphur trioxide. At any rate, this acid forms true compounds with water, which may perhaps be called hydrates. When it is mixed with water, not only does the resulting product occupy less volume than did the water and the sulphuric acid before they were mixed, but there is also the evolution of much heat, which, as the doctrine of the conservation of energy teaches us, has to come from somewhere, and which implies the satisfaction of potential chemical energy previously present in the sulphuric acid and the water, and the transformation of that energy into the form of kinetic energy which we call heat [see PHYSICS].

Uses of Sulphuric Acid. Thus, sulphuric acid may be used in order to dry gases and other bodies; and probably the most marked of its properties in relation to living matter are due far less to its character as an acid, though this is marked enough, than to its character as a withdrawer of water, or a dehydrator. This process of dehydration, or the removal of water, causes the characteristic marks of the action of sulphuric acid. We saw that nitric acid turns the skin yellow; pure sulphuric acid makes it black, and has the same action on wood and sugar. Indeed, it chars these substances, and the black is simply carbon.

The case of sugar is the simplest, because this, as we shall afterwards see, is a carbohydrate—that is to say, a substance consisting of carbon, hydrogen, and oxygen, the two latter being present in the same proportions as they are in water. Thus, to speak somewhat loosely, the reason why sulphuric acid chars sugar is that it removes all the water—strictly speaking, the elements equivalent to water—that enters into its composition, leaving merely the charcoal behind. The acid has countless practical uses—in the preparation of other acids, as we have already seen, and in the manufacture of sodium carbonate and caustic soda, these being quoted from hundreds.

Sulphates. Certain sulphates have already been referred to. We may note the names of *calcium sulphate* ($CaSO_4$), which, under varying conditions, is known as gypsum, alabaster, and plaster of Paris; *magnesium sulphate* ($MgSO_4$), which abounds in the mineral springs at Epsom, and hence is called Epsom salts; *zinc sulphate*, which is an antiseptic and astringent, and thus also of value in medicine; *ferrous sulphate* ($FeSO_4$), which, having nothing to do with copper, is unfortunately known as *copperas*, or, much better, as *green vitriol*; *copper sul hate* ($CuSO_4$), known as *blue vitriol*—the term "vitriol" or "oil of vitriol" being often applied to strong sulphuric acid. The word is derived from the Latin *vitrum*, glass, since the acid and many of its compounds in certain states have a glassy appearance. But there is a further class of sulphates to which special reference must be made.

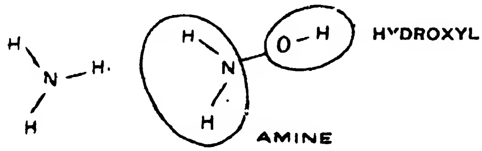
Alums. The word *alum* is very frequently confined to what should properly be called potash alum; but, in the general sense, an alum is a double sulphate, consisting of the sulphate of one of the alkali metals together with a sulphate of aluminium or one of the metals belonging to the aluminium group. They all correspond to potash alum, the formula of which is variously rendered, as intelligible a reading as any being $KAl(SO_4)_2, 12H_2O$. They all form eight-sided crystals, so that if a crystal of one of the alums be placed in a solution of another, the crystal is covered by a crystalline layer derived from the solution. This is made the more easily possible since they all contain the same number of molecules of water of crystallisation. All the alums are readily soluble in water, they all have an astringent taste, and an acid relation to litmus paper and the like. Thus, in every way, they form a very definite class. The most important alums, after potash alum, which has been so long known, are those containing ammonia, chromium, iron, and manganese. The chief use of ordinary alum—that is to say, potash alum—is as what is

called a mordant (from the Latin *mordeo*, I bite) —that is to say, a substance which so affects cloth dipped into it that any colouring matter afterwards employed stains the fibre much more permanently. This is due to the relation of alum to colouring matters, with which, as we have seen, it forms the precipitates called *lakes*.

Many other oxides are of importance, and some of them have been previously referred to, but we must pass them and discuss a few other compounds, which are mostly of small importance in themselves, but are of interest because some of them introduce us to fresh complexities, the memory of which may help us when we pass on to organic chemistry.

Derivatives of Ammonia. Ammonia (NH_3) may, of course, be described as a nitride of hydrogen, and in referring to the alkaloids we have seen the theoretical importance of this substance, since one or more of the hydrogen atoms may be replaced by innumerable atomic combinations, such as those which constitute the alkaloids. But there are other nitrides of hydrogen. That which has the formula N_2H_4 resembles ammonia, and is known as hydrazine.

Of much greater interest is the compound with the formidable name *hydroxylamine*. This name, however, has good sense in it. The first part of it, *hydroxyl*, is applied to the atomic group, $-OH$, which is found in combination with so many other kinds of atoms and groups of atoms, the simplest case, of course, being water, the formula of which may be written $H—OH$. The meaning of the term *hydroxyl* must be carefully remembered, since, though hydroxyl never exists by itself, it is one of the most frequent and important atomic combinations in the whole range of chemistry. *Amine*, the rest of the long word we have quoted, is the name of an almost equally important atomic group, NH_2. Hence the formula of hydroxylamine is given in its name, once the meaning of the name is explained. It is, of course, NH_2OH. Now, suppose this were written in the shortest possible way, it would run NH_3O, and there would be no comprehension of the presence of the hydroxyl group, but if we write it properly, NH_2OH, we see that this substance may be regarded as ammonia, one hydrogen atom of which has been replaced by hydroxyl. We may even, by way of illustrating the meaning of the graphic formulas to which we must soon come, venture on a little drawing to show what may be supposed to have happened. The lines represent the "hands" of the atoms.



Hydroxylamine is known in solution in water as an alkaline liquid. When this is distilled some of it passes off unchanged, while the rest is decomposed, forming ammonia. As may be expected, if we compare the formula of hydroxylamine with, say, the formula of caustic potash (KOH), this substance is an alkali, and forms salts with acids. In looking at the formula of caustic potash, we recognise the last two letters as constituting the hydroxyl group.

The Amides. Hydroxylamine is also of importance, as we may use its formula in order to remind ourselves that hydroxyl and amine can take each other's places in various compounds. For instance, there are known compounds called *sodamine* (or sodium amide) and *potassamine*, the formulas of which are $NaNH_2$ and KNH_2, obviously corresponding to $NaOH$ and KOH, the amine group having taken the place of the hydroxyl group. These are simple instances of the countless compounds of ammonia.

Another compound, which is of importance because it is so often put to practical ends, is the substance which is popularly known as *white precipitate*. This is a compound of ammonia and perchloride of mercury or corrosive sublimate, and its formula may variously be written. If a solution of corrosive sublimate acts upon ammonia, this body is formed. Its composition may be most conveniently written NH_2HgCl, though the reader will remember that $HgCl_2$ is the formula of perchloride of mercury, not $HgCl$. This last, however, is the formula of the subchloride of mercury, or mercurous chloride, and this has a similar interaction with ammonia, forming a substance of no importance.

Phosphoretted Hydrogen. Phosphorus, we remember, belongs to the nitrogen group of elements, and so, if the grouping of the elements means anything, we may reasonably expect that there should be compounds of the other elements of this group with hydrogen, corresponding to the compound ammonia, and this is so. For instance, we know the phosphorus compound, which naturally has the formula PH_3, the arsenic compound (AsH_3) and the antimony compound (SbH_3).

Of these, by far the most important is phosphoretted hydrogen, often called phosphine (the others are similarly sometimes known as arsine and stibine). Like ammonia, phosphine is a colourless gas, poisonous, having a horrible smell, but, unlike ammonia, insoluble in water. It may be formed in various ways, as, for instance, by boiling a strong solution of caustic potash containing free phosphorus. In these and other methods of manufacture, great care has to be taken to dispose of another phosphide of hydrogen (P_2H_4), which is liquid and is spontaneously inflammable in the air, even at ordinary temperatures. Now, the parallelism between phosphine and ammonia is still further illustrated by the fact that with certain acids it forms salts which precisely correspond to the salts of ammonium. For instance, there is the salt called phosphonium bromide, which has the formula PH_4Br, and which exactly corresponds, both in its mode of formation and otherwise, to ammonium bromide (NH_4Br).

C. W. SALEEBY

HOW THE HERMIT WAS LED TO THE VATICAN

CELESTINE V. BROUGHT FROM HIS MOUNTAIN HERMITAGE TO BE POPE AT ROME

The Duel Between France and the Italian Papacy. Popes at Avignon. The Council of Constance, and the Return of Religious Persecution.

THE DAYS OF RELIGIOUS CHAOS

LET us now see how the fall of the Hohenstaufen House affected the fortunes of its great enemy, the papacy. In 1294, on the occasion of a papal vacancy, the cardinals, divided among themselves, and tired of one another's intrigues, took the unexpected step of choosing as pope a holy hermit in the mountains of the Abruzzi, who most unwillingly donned the papal crown and took the title of Celestine V. It was soon seen, however, that a great saint might make a very bad pope. This wild man from the mountains, with his shaggy beard and vile raiment, though kings held the bridle of his ass as he rode into the city of Aquila, could not adapt himself to the splendour of his new position, or manage with decent ability the complicated affairs of his world-wide spiritual kingdom.

Almost at once he began to meditate abdication, and a return to the roots and water of his cell; and one of the cardinals, the astute Benedetto Gaetano, was ever at his ear whispering that this would be his wisest course. In December, 1294, after little more than four months' pontificate, Celestine abdicated—if a pope could abdicate—his great office, making, as Dante says, "through cowardice, the grand refusal," and was succeeded by his benevolent adviser, Gaetano, who took the title Boniface VIII., and before long committed his predecessor to a strict imprisonment in a noisome dungeon, from which, after a few years' captivity, he was released by death.

In the pontificate of Boniface VIII. the papal power seemed to reach its greatest height, only to undergo its most terrible humiliation. He out-Hildebranded Hildebrand in the language which he addressed to kings and emperors. "There are two swords," he said, quoting the words of Christ in the garden. "These are the spiritual and the temporal. One sword must be under the other—the temporal under the spiritual. The spiritual instituted the temporal power, and judges whether that power is well exercised. We assert, define, and pronounce that it is necessary to salvation to believe that every human being is subject to the pontiff of Rome."

For a time all went well with the haughty and grasping Boniface. He banished the whole family of the Colonnas, his personal enemies, he razed their fortresses, and forbade their city of Palestrina to be rebuilt. He imposed peace on the warring kings of England and France. He proclaimed a Jubilee in the year 1300; men, women, and children flocked to Rome to obtain eternal salvation; and two priests stood by the altar of St. Peter's with rakes in their hands, sweeping in the gold and silver coins offered by the pilgrims. It was said that during this Jubilee Boniface wore an imperial crown as well as the papal; that the purple sandals of the emperor were on his feet, and that two swords, signifying temporal and spiritual power, were borne before him.

But this man, so proud and domineering, met his equal in the king of France, Philip the Fair, grandson of St. Louis, and in all things the opposite of his sainted ancestor. Hard, covetous, and revengeful, Philip came into collision with Boniface over his claims to tax the revenues of the Church, and he found his pretensions ably supported by the rising school of lay lawyers, who magnified the office of Cæsar as much as the ecclesiastical lawyers magnified the office of the Vicar of Christ. The pope thundered forth his bulls; the French king replied with his angry decrees. There were excommunications on one side, outlawry and confiscation on the other; but it was plain that Philip had the majority of his subjects on his part, and that he would not have to go to Canossa or feel on his neck the pressure of the pontiff's sandal.

Far from this, he and his legal advisers began to moot the question of Boniface's own right to the popedom, the weak point in which was, of course, his election during the lifetime of his predecessor, and to press for his trial before a general council on some strange and scarcely credible charges of heresy, blasphemy, and

immorality. But ere such a council could be summoned, Boniface—who, to avoid the heat of a summer in the city and the turbulence of Roman citizens, had retired to his native town of Agnana—was attacked there by a band of ruffians; headed by one of his old enemies the Colonnas, and by a myrmidon of Philip, William of Nogaret; and by these men and their followers he was so roughly handled that in less than five weeks he died.

The Seventy Years' Captivity of the Popes. The assailants and all but murderers of the pope were never punished, but, on the other hand, the memory of Boniface was spared that solemn condemnation which Philip longed to inflict. The influence of the French king, however, was now triumphant at the papal court; one Frenchman after another was raised to the papacy and came to nestle under the wing of French royalty at Avignon, on the Rhone. Avignon was not at this time actually part of the French territory, though closely bordering upon it. Thus began the Seventy Years' Captivity which amazed and scandalised Europe. For the greater part of the thirteen-hundreds, from 1305 to 1376, during the hottest of the war between Edward III. and the Valois kings, we must think of the Pope as the humble client of the French king; it might be said hardly more than his domestic chaplain.

The Suppression of the Knights Templars. It was in this position of meek subordination to the king of France that Clement V., the first Avignon Pontiff (1305-1314), sanctioned the suppression of the Order of Knights Templars, on account of their alleged immorality, heresy, and secret practising of obscene and blasphemous rights. For these alleged crimes, mainly on the strength of confessions extracted by torture, the aged Grand Master of the Order, John du Molay, and 113 of the knights were burned in Paris. Hundreds perished in the French prisons. In England the Order was also suppressed, and some of its members appear to have been subjected to the torture, but the punishment was for the most part limited to lifelong seclusion in a convent. The degree of justification for the suppression of the Order of Knights Templars is one of the disputed questions of history, and in some respects resembles the similar question with reference to the suppression of the English monastic orders in the fifteen-hundreds.

Greed Masquerading as Purity. In both cases bitter and terrible accusations were brought against the incriminated parties, and it is not easy to understand how these rumours can have arisen absolutely without cause; but in both cases also the chief crime of the accused was evidently their large possessions, which attracted the desires of a greedy and extravagant king—in England, Henry VIII.; in France, Philip the Fair. The execution of Grand Master du Molay especially moved the pity of Europe, which heard of the martyr's dying summons to king and pope to meet him speedily before the bar of the Most High—a summons which was followed by the death of Clement V. within thirteen months and of Philip IV. within twenty-one months of the murder of their victim.

The Papacy Overshadowed by France. The sojourn of the Popes for more than two generations at Avignon is one of the strange paradoxes of mediæval history. How, we ask ourselves, was it possible for ecclesiastics whose sole title to the obedience of the Church lay in the fact that they were bishops of Rome to spend the whole of their official lives in a city on the Rhone, a month's journey from the imperial city? Theoretically, the position was certainly indefensible. Practically, it is easy to see how the thing came to pass. The French influence, having once become strong in the College of Cardinals, tended to become ever stronger, because each French Pope created more and more of his own countrymen. The king of France, not yet engaged in his deadly struggle with England, overshadowed the weak Bohemian emperors of Germany.

Failure of the Italian Republics. Italy, now that the emperor was no longer in any sense arbiter of her destinies, was falling into a state of disorganisation, city warring against city, and almost every city having its own knot of exiled citizens who were yearning to return to their homes and to wreak vengeance upon their opponents. After a short and glorious existence, the Italian republics in the thirteen-hundreds were falling one by one under the yoke of tyrants—in the Greek sense, masters of a city which had been free—the Visconti at Milan, the Della Scala at Verona, Castracani at Lucca, and so forth. Florence, the great Guelf city, it is true, was still free, though sorely tossed by faction, and Venice, that marvel of aristocratic statecraft, had naught to fear in the way of tyranny from her curbed and muzzled Doges.

Government by Hire of the Free Companies. But elsewhere the Republicanism which had largely prevailed in Italy under the theoretical rule of the Franconian and Swabian emperors was giving place to a form of government which was not feudalism, still less constitutional monarchy, but the irresponsible, unlimited, often cruel *governo d'un solo*. In the States of the Church turbulent barons alternated with turbulent democracies, and both, as opportunity offered, availed themselves of the assistance of those predatory bands of soldiers, representing no nationality and responsible to no sovereign, who were called condottieri, or free companies, and who were, unfortunately, to a large extent the outcome of the long and devastating wars of the Plantagenets in France.

The Noisome Pestilence. In addition to these troubles came the terrible scourge of the Black Death—perhaps the most awful pestilence that the world has ever seen, which from 1346 to 1368 swept over Europe, destroying in some regions as much as two-thirds of the population, and, on an average, of the whole probably not less than a quarter. From these varied causes the condition of Italy in the middle of the thirteen-hundreds was doubtless

a sad one; and it is not perhaps surprising that the pope and his cardinals, for the most part Frenchmen, should have preferred the splendid, semi-regal fortress-palace of Avignon and their luxurious villas by the Rhone in beautiful Provence to the fever-haunted streets of alien Rome. For a short time it seemed as if the great absentee landlord would lose his hold upon the property from which he took his title.

The Meteoric Rienzi. The splendid dreamer Nicolas Gabrini, who is known to history by the name of Rienzi, musing on the miserable state of Rome, agitated as she was by the faction fights of turbulent nobles, and comparing it with the calm majesty of the old Roman Republic, as revealed to him by inscriptions in the Forum, and interpreted by the pages of Livy, decided to call his fellow-citizens to revolt, and assumed the historic title of Tribune (1347-1349). He was marvellously successful for a time; the proud nobles, the Orsini and the Colonnas, were awed into silence and submission, and the papal legate found it expedient to be a humble partner in the tribune's administration. But Rienzi's record in history is essentially meteoric. As a meteor he burst upon Europe; as a meteor he fell, the victim partly of his own vain, unstable character. If he had possessed the brave, modest nature of a Garibaldi, he might, perhaps, have changed the course of history and re-established, half a millennium ago, the Roman Republic. But he was only Rienzi, and his meteor-light left the sky dark behind it.

The Pope's Return to Rome. The Seventy Years' Captivity at Avignon, itself somewhat of a scandal, died out in the greater scandal of the Forty Years' Schism. Under the earnest pressure of the public opinion of Christendom, as represented by such enthusiasts as Catharine of Siena, Pope Gregory XI. returned to Rome for a visit, which proved to be a farewell visit, for he died there early in 1378. Where the pope died, there must the Conclave be held. The cardinals assembled in Rome to choose a new pope, appalled by the furious shouts of the populace, who demanded a Roman, or at least an Italian, pope, went outside their own college—more than half of whom were Frenchmen—and elected Bartolommeo Prignani, an Italian of low origin, but skilled in the canon law and famed for his piety, who took the title of Urban VI.

A Mob-made Italian Pope. The humble monk, when raised to the papal throne, developed qualities of insolent and ferocious pride, some of the manifestations of which seem to indicate a vein of lurking insanity. The luxurious and high-born cardinals found themselves restricted to one dish at dinner, and heard their new master bellow at them such courtesies as: "You have talked long enough," "Hold your tongue," and so forth. Worst of all, the pope declared his intention of remaining in Rome, and was about to make a large creation of Italian cardinals in order effectually to bar the way of a return to Avignon.

Rival Popes—Both Wanderers. At this, a large party of cardinals, chiefly Frenchmen, broke away from their allegiance, declared the election of Urban invalid, as having been made under duress from the Roman mob, and elected as pope the high-born soldier-cardinal Robert of Geneva. He took the name of Clement

JOHN HUSS AT THE COUNCIL OF CONSTANCE

VII., and ere long found his way back to Avignon, and, though with diminished splendour, kept high court there, like the six popes before him. His rival remained in Rome, or, when frightened thence by the turbulence of the mob or by the soldiers of the Queen of Naples—with whom, though Neapolitan born, he had continued to quarrel—he took up his abode at Genoa, at Lucca, at Perugia, at any Italian city which could give him a constrained welcome.

National Cleavages for the Rival Popes. The chief Powers of Europe ranged themselves under one or other of the rival banners. Northern Italy, Germany, and England were in obedience to Urban VI. France, Spain, Scotland, and Naples were in obedience to Clement of Avignon. It will be seen how large a share national quarrels had in determining ecclesiastical partisanship. France, of course, took the side of the pope who hankered after pleasant Avignon; Germany and England, as foes to France, took the side of his rival; Scotland, as deadly enemy to England, followed the lead of France.

Willing to Forgive, but Not to Submit. The schism thus begun lasted, as has been said, for nearly forty years. When Clement VII. died, in September, 1394, a successor to him was chosen, who took the title of Benedict XIII. To his rival, who had died five years before, three popes in succession were elected by the Italian cardinals, the last of these being the octogenarian Gregory XII. (1406-1417). At each election the same professions of earnest desire to end the schism were clamorously repeated, and each successive pontiff expressed his willingness to abdicate if his rival would do the same. "I would abdicate," said Benedict XIII., before his election, "as easily as I take off my hat." "I long for a conference which shall restore unity," said the venerable Gregory XII. "If there is not a galley to take me to the place of meeting, I will go in a fishing-boat. If horses fail for the land journey, I will take my staff in my hand and will go on foot." But practically all yearning after conciliation and compromise resolved itself into a willingness to accept the unconditional surrender of the opponent. Each pope would graciously allow the anti-pope to kiss his foot, but was invincibly resolved not to perform the converse operation.

THE EMPEROR SIGISMUND

Three Rival Popes at Once. The anarchy of the Church reached its climax when, at the Council of Pisa in 1409, both the rival popes were called upon to resign, and a devout Franciscan friar was elected in their stead, under the title of Alexander V. But the existing popes, though formally deposed, refused to accept their deposition, and it was soon evident that the council, instead of ending the schism, had only widened it by adding a third pope to the list. More dreadful was the entanglement when, after the short pontificate of Alexander, the tiara was bestowed upon a man who, though a cardinal, was little better than a general of condottieri, Baltasare Cossa, who took the title of John XXIII. The well-meant endeavours to end the schism had but ended in the election of one of the most disreputable pontiffs who ever sat in the chair of St. Peter.

The Stupendous Council of Constance. The extraordinary evil called for an extraordinary remedy. This was none other than the far-famed Council which assembled at Constance under the presidency of Sigismund, last emperor of the House of Luxemburg, and which sat for three years and a half—from November, 1414, till May, 1418. The assembling of this council—at which 29 cardinals, three patriarchs, 33 archbishops, and 2400 other ecclesiastics from all parts of Europe were present, besides 100 dukes and earls, 2400 knights, and 116 representatives of cities—was one of the greatest events of the Middle Ages. Had it corresponded to the jubilant expectations formed of it, the Council might have been their glorious finale.

Three Obstinate Old Popes Deposed. Much had been hoped for from the assembling of so many grave and learned men, especially in the reformation of abuses which, in the course of ages, had crept into the administration of the Church. What was accomplished? The obliteration of the three obstinate old men, each of whom persisted in calling himself the Vicar of Christ, and the election in their stead of a capable and respectable Italian noble of the House of Colonna, who took the title of Martin V. This was a wise and statesmanlike act, though some think that even after the lapse of three years the Council showed undue haste in electing a pope before, instead of after, passing those measures of reform which became

THE POPE WHO TORTURED HIS CARDINALS

URBAN VI., HEARING OF A PLOT AMONG HIS CARDINALS, SOUGHT TO EXTRACT INFORMATION BY TORTURE, WHICH HE ENCOURAGED BY RECITING HIS BREVIARY OUTSIDE THE TORTURE-CHAMBER
Reproduced from the painting by the Hon. John Collier, by permission of the artist.

practically unattainable after it had given itself a master in the person of Pope Martin.

Two Devout Protestants Burned. Not so wise or so statesmanlike were the acts by which the Council sought to demonstrate its own orthodoxy—the burning of John Huss and Jerome of Prague, two devout and learned Bohemians who, in the spirit of Wiclif, and partly in consequence of his teaching, had defended what would now be called the Protestant position against the mediæval papacy. In the case of Huss, this murder was especially to be condemned, as he had come to Constance of his own free will, trusting to a safe-conduct which he had received from the emperor. Of this fact he reminded Sigismund when he stood before his tribunal to receive his condemnation, and it is said that the emperor blushed with shame. Practically, a pope elected and two heretics burned were all the outcome of this memorable and long-labouring Council.

Advisory Council or Monarchical Pope? Underlying the discussions on temporary points of policy at the Council of Constance was the important question of the constitution of the Church. If the power of an œcumenical council could be magnified, if its sittings could be repeated at short and regular intervals, if it could be made impossible for the pope to take any important step without its advice, the constitution of the Church would become aristocratic; if Martin V. and his successors could succeed in negativing the proposals, and could keep the papacy on the old lines on which it had moved from Hildebrand to Boniface, it would remain monarchical. The second alternative event was that which actually happened. Council after council was held during the thirty years after the Council of Constance; Basle, Ferrara, Florence, each had its council, the first defying the pope, and even renewing for a time the misery of the schism, the second and third working with the Roman pope and effecting a short-lived reconciliation between the Latin and Greek Churches. But all ended in a re-establishment, apparently on a firmer basis than ever, of the papal supremacy; and our fourth period closes with the pontificate of Nicolas V., a lover of peace, a lover of the arts, and one of the best of the mediæval pontiffs. He is said to have died of grief on hearing of the fall of Constantinople.

The Importance of the Papal Question. Let it not be thought that in this brief sketch too large a space has been given to ecclesiastical affairs. The history of the papacy in the centuries that we have been lately traversing is really central in the history of Europe. Financially, the enormous drain of bullion to Rome or to Avignon, in order to meet the demands of the papal tax-gatherers, diverted the course of commerce, created the profession of bankers, sometimes helped and sometimes hindered the struggles of English Parliaments with their kings. And in the purely political domain, in the war of dynasties and the collision of nations, the papal question played a most important part. Anyone who studies the history of Naples, of Florence, of Milan, of Bohemia, and of Hungary, or reads the story of the wars between England and France, will find his steps continually dogged by the Seventy Years' Captivity and the Great Schism. It is worthy of note that Agincourt was fought in the first year of the Council of Constance, and that, in the interests of his schemes for papal reform, Sigismund tried to arrange a truce between France and England.

THOMAS HODGKIN

RIENZI THE TRIBUNE IN THE FORUM AT ROME

Stability Against Overturning and Crushing. Boundary Walls. Buttresses. Retaining Walls. Surcharged Walls.

THE STABILITY OF WALLS

General Principles. The simplest case of the stability of a wall will occur when the wall is considered to overturn by pressure on one face without crushing the edge, which acts as a fulcrum. This can happen only when the total weight of the wall is very small. It is usual to consider one foot of the length of wall, as every foot will be similar, except in the case of walls with buttresses or counterforts. In 1 is shown the section of a wall, ABCD, of weight w per foot cube, height h, thickness t, total weight W, acted upon by a pressure p per square foot against one face, giving a total pressure P. Then $W = wht$, acting at the centre of gravity of the wall, and $P = ph$, acting at the centre of the height. Produce P through the centre of gravity of the wall and drop W from the same point, then find the resultant of the two forces by means of the parallelogram of forces. So long as the resultant cuts the base line within the wall, the wall will be in stable equilibrium; but should the resultant cut the base outside the wall, the wall will overturn. To find the maximum pressure per square foot for equilibrium,

$$\tfrac{1}{2}h : wht :: \tfrac{1}{2}t : ph,$$

whence,

$$ph = \frac{wht \times \frac{1}{2}t}{\frac{1}{2}h} = wt^2;$$

or,

$$p = \frac{wt^2}{h}.$$

From this equation it will be seen that the stability varies directly as the weight per cubic foot and as the square of the thickness, and inversely as the height. It must be observed also that the moments of the forces are equal—*viz.*,

$$P \times \tfrac{1}{2}h = W \times \tfrac{1}{2}t.$$

There is another possible mode of failure without crushing, and that is by pushing the wall off its base. This may happen if the wall is very thick compared with its height, and the pressure against the face is sufficiently great to cause the wall to slide without overturning. The coefficient of friction of fresh mortar may be taken as 0·5, so that when $P = \frac{1}{2}W$ and the resultant cuts the outer edge of base, the tendency to overturn or slide will be equal.

Distribution of Pressure on Base of Wall. A wall of rectangular section, built upright, and subject to its own weight only, produces a uniform pressure over the base, because the resultant meets it in the centre, as shown in 2. The diagram at base of wall represents the ordinates of pressure. If a pressure acts against the wall horizontally at any point, the amount of total vertical load is not altered, but the resultant, or centre of pressure on the base, is pushed further over, causing an increase in the intensity on the outer edge and a reduction on the inner edge. If the horizontal pressure be sufficient to push the resultant over to the edge of the *middle third* of the base, as shown in 3, the pressure will be increased to double at the outer edge and reduced to nothing at the inner edge. A wall under such conditions is generally considered to be absolutely safe, but it may not be really so, as the height, and consequently the weight, may be so great that doubling the pressure on the outer edge may produce a greater intensity than the material is capable of bearing. On the other hand, the resultant may pass beyond the middle third and the intensity of pressure still not be so great as to exceed the safe stress upon the material.

Resultant Beyond Middle Third. When the resultant passes beyond the middle third of the base, there are two cases to consider—one where the material will not bear any tension, and the other where tension may be allowed. Taking the former case, and assuming that the resultant passes at one-fourth the width of base from the outer edge, the maximum pressure in tons per square foot will be

$$p = \frac{2}{3} \cdot \frac{W}{d},$$

where W = total load in tons, and d = distance from resultant to outer edge in feet. Graphically, the triangle giving the ordinates of pressure will be carried back along the base twice the distance d from the resultant towards the inner edge, and the remainder of the base will be under no pressure, as in 4. This formula is due to Professor Crofton, of the Royal Military Academy, Woolwich, and is generally accepted as giving a true result, although there are other possible views of the case.

When tension is permissible, the maximum pressure at outer edge and tension at inner edge are given by the formula

$$p = \frac{W}{A} \pm \frac{M}{Z},$$

where W is the vertical component of the resultant, A the sectional area of the base, M the bending moment—*i.e.*,

$$W(\tfrac{1}{2}t - d),$$

and Z the modulus of section—*i.e.*,

$$\tfrac{1}{6}(t \times 1^2) = \tfrac{1}{6}t;$$

the + value giving the intensity of the compression and the − value the intensity of the tension, as shown in 5.

Boundary Walls. A boundary wall when newly built will come under the rule for 4,

but when the mortar has set it will be to the rule for 5. The safe proportions for thickness and heights of boundary walls are given in the following table.

SAFE PROPORTIONS FOR BOUNDARY WALLS.

9 in.	Up to	6 ft. 4½ in. high.
14 ,,	.. ,,	9 ft. 7½ in. ,,
18 ,,	.. ,,	13 ft. 0 in. ,,
23 ,,	.. ,,	16 ft. 6 in. ,,
27 ,,	.. ,,	20 ft. 4½ in. ,,

Stability of Buttresses. A buttress may be calculated as part of a wall, in which case the length is taken to include one buttress and the wall for half the distance towards the other buttresses on each side. This is, however, rather a troublesome calculation, and a buttress is often calculated by itself, especially when it is a large one to take the thrust of a roof truss, as with public halls and churches having hammer-beam trusses. The thrust upon each part of a buttress and the weight above the horizontal line for which the calculation of stability is made, are combined in a parallelogram of forces; but it will first be necessary to find the vertical line through the mean centre of gravity. This is most easily done by marking the centre of gravity of each part, as in **6**, and drawing force-lines through the points to meet the base. The weight of each part may be taken as acting through its centre of gravity to give the value of each force, and then. the load-line [**7**], being drawn, a pole is selected and vectors drawn from the points on the load-line to the pole. The force-lines in **6** may then be drawn down on to a separate line, like a beam [**8**], and the funicular polygon constructed by drawing lines parallel to the vectors, when the intersection of the closing lines A and D gives the position of the mean centre of gravity.

Another method of finding the mean centre of gravity of any number of separate parts is shown in **9**. First mark the centre of gravity of each part A, B, and C, then join A and B and at any angle draw a line upon which the weights of A and B are to be set off to scale in inverse order, as shown by *ba*, join the extremity with B. and at the junction of *a* and *b* draw a parallel line to cut AB at the mean centre of gravity. Join this with point C and repeat the operation as indicated, when the mean centre of gravity of the whole figure will be obtained. Applying these principles to an actual buttress [**10**] it will be necessary to ascertain the stability at each minimum section, thus, at A and B. Find the centre of gravity of the portion above A, and then of the part between A and B. Taking the part above A, first combine by parallelogram of forces the thrust and the weight to give the resultant shown, which is found to cut the base just within the middle third; then, producing this resultant, combine it with the next thrust to produce another resultant. It will be well to reduce the scale wherever necessary to prevent the parallelogram becoming unwieldy, as in this case. The last resultant will now be combined with the new weight and a new resultant will be found which also cuts the base just about the edge of middle third. This will show that the buttress is safe provided the intensity of the pressure be not too great. This pressure, with the resultant at edge of middle third, will be $= 2 \times \frac{W}{A}$, where W is the vertical component of the resultant and A the area of base.

Stability of Retaining Walls. A retaining wall is a wall of brick, stone, or concrete to hold up the earth at a change of level, as in a railway cutting through a town where there is not sufficient space available to allow of side slopes being formed. The pressure of the earth depends upon its *natural slope*—that is, the slope it would permanently retain if a bank of it were left exposed to the weather for an unlimited time. It may be taken generally as 30 degrees from the horizontal when the conditions are unknown, but the following table shows the natural slopes for ordinary soils as given by Rankine:

TABLE OF NATURAL SLOPES.

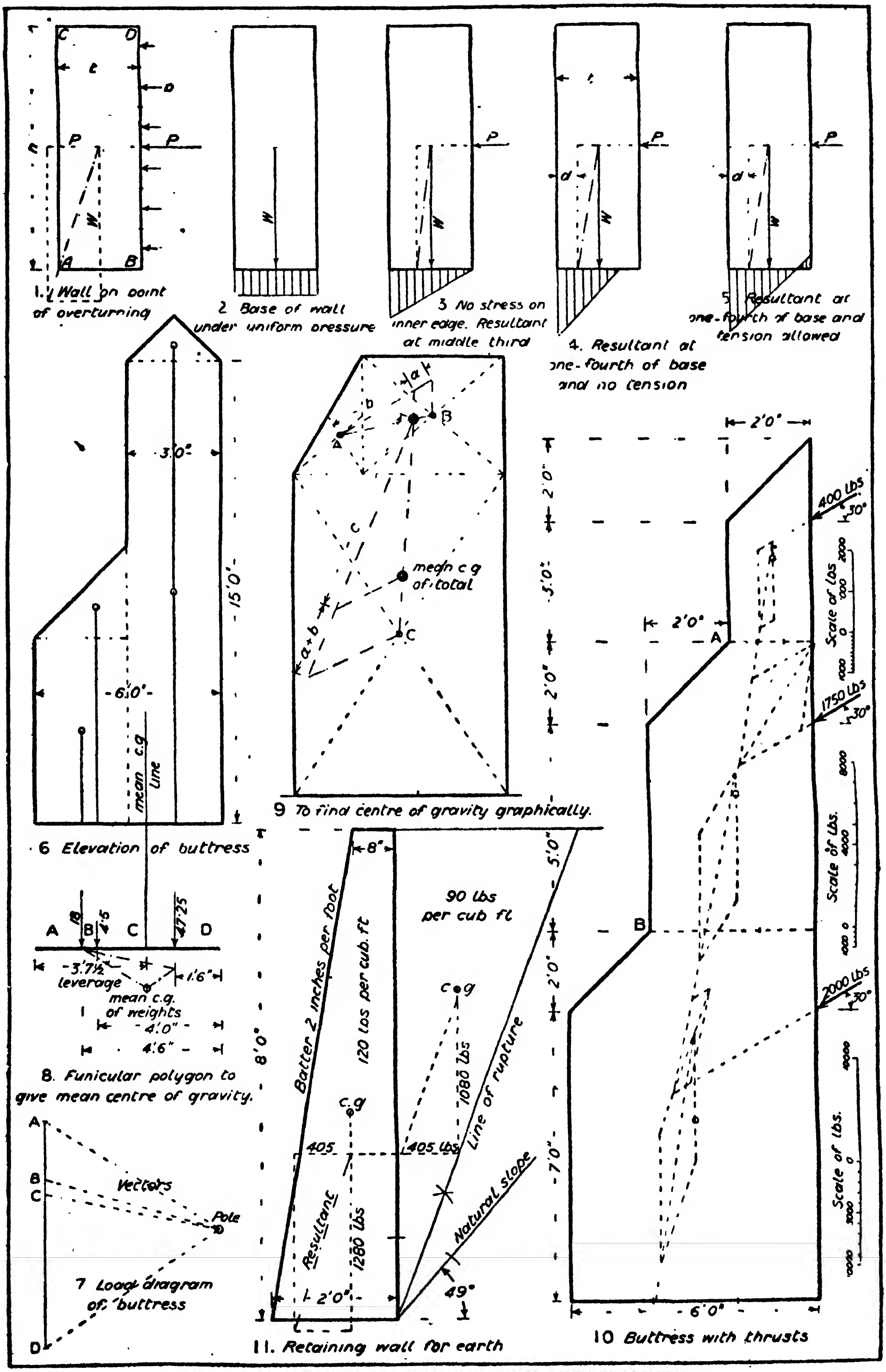
	Degrees.
Dry sand, clay and mixed earth ..	21 to 37
Damp clay	45
Wet clay	14 to 17
Shingle and gravel	35 to 48
Peat	14 to 45

This angle is sometimes called the *angle of repose*, but it means the same thing, as in the following table from "Notes in Building Construction," Vol. IV.:

ANGLE OF REPOSE OF VARIOUS EARTHS.

	Degrees.
Fine dry sand	37 to 31
Sand, wet	26
Vegetable earth, dry	29
,, ,, moist	45 to 49
,, ,, very wet	17
,, ,, consolidated and dry	49
Loamy earth, consolidated and dry	40
Clay, dry	29
,, damp, well drained	45
,, wet	16
Gravel, clean	48
,, with sand	26
Loose shingle	39

Everyone knows by personal experience that an overturning pressure may be most easily resisted by leaning against it, and the principle holds equally well with retaining walls. A wall to resist the pressure of earth will need less bulk in proportion as it can be leaned against the earth. The reason is that the centre of gravity is thrown further back, so that the weight of the wall acts with greater leverage. The usual form of section is shown in **11**, and the mode of working to ascertain the stability is indicated by the dotted lines. A given section has first to be assumed and then its stability determined. The line indicating the natural slope according to the material is put on at the back of the wall, starting at the level of the horizontal section where the stability is to be determined. Then the angle between the natural slope and the vertical is bisected to give



1–11. STABILITY OF WALLS AND BUTTRESSES

the line of rupture; this may be considered as the line of fracture of the earth if the wall should overturn, or the primary angle at which the earth would stand unsupported, the natural slope being the ultimate angle after long exposure to the weather. The wedge of earth between the line of rupture and the back of the wall may be considered to press against the wall without friction. Its centre of gravity must be determined and its weight calculated, then, dropping a vertical line from the centre of gravity to meet the line of rupture, a length is measured upwards to any given scale to represent the weight of one foot run, and from the top of this measurement a line is drawn parallel to the line of rupture to cut a horizontal line from the junction with the line of rupture. The horizontal length so cut off gives the thrust upon the wall at one-third of the total height. Now, the centre of gravity of the wall must be found and the weight of one foot run calculated; then the thrust of earth and the weight of wall are combined by the parallelogram of forces to give a resultant, which in this case cuts the base at a distance of 0·416 ft. from the outer edge. By the formula $\frac{2}{3} \cdot \frac{W}{d}$ the maximum intensity of pressure upon the outer edge of base is found to be 0·9 ton per foot super.

Surcharged Retaining Wall. When the earth rises higher than the wall by reason of a sloping bank above it, the wall is said to be surcharged. Such a wall is shown in **12**, and the method of finding the thrust is as follows. Having drawn to scale the assumed section of wall and the earth at back, produce the line of slope of surcharge indefinitely through the wall, and from point A set out the angle θ equal to the natural slope of earth. Produce this line to cut the continuation of slope of surcharge in point B, then the horizontal thrust in pounds at point C, which is one-third the height of back of wall, will be $\frac{1}{2}w(AB)^2$, where w = weight of earth in pounds per cubic foot, and AB = length in feet, then $\frac{1}{2} \times 112 \times 9{\cdot}8^2$ = say, 5,380 lb. set out as CD. Next, from D draw a vertical line and from C draw a line parallel to the natural slope to cut this vertical in point E, then CE will be the thrust on back of wall and will be found to equal about 6,550 lb. Producing this in the usual way and combining with weight of one foot length of wall, the resultant will be found to cut the base at a distance of 1·1 ft. from point F, then by the formula

$$\frac{2}{3} \cdot \frac{W}{d} = \frac{2 \times 8800}{3 \times 1{\cdot}1} = \text{say, } 5330 \text{ lb.},$$

or about 2·4 tons per square foot maximum compression on the wall.

Retaining Wall Loaded at Back. When a warehouse is built on the earth at the back of a retaining wall, or a large crane is fixed there, or a line of rails on a roadway runs near, the thrust upon the wall will be increased beyond that due to the weight of the wedge of earth. An approximate method of finding the thrust in such a case is shown in **13**. The difference from **11** is that an additional thrust due to the external load has to be combined with the ordinary thrust as follows: From the point of application A of the external load nearest the wall draw a line parallel with the line of rupture to cut the back of the wall in the point B, and from B set out BC horizontal, so that the point C is directly under the point A; next set up CD equal to the load on point A and make DE parallel with the line of rupture, then CE will be the amount of thrust due to load A acting on the back of wall at point B. Combining this with the weight of wall acting through its centre of gravity will give the first resultant, FG. Next, find the horizontal thrust due to the wedge of earth acting at one-third the height of back of wall and combine with FG, giving the second resultant, HJ. Then, treating the other load on the surface in exactly the same way as the load at point A, the horizontal thrust acting at point K will be LM, and combining this with the second resultant, HJ, the final resultant, NO, will be obtained, cutting the base of wall at a distance of 0·9 ft. from the toe P, when, by the formula

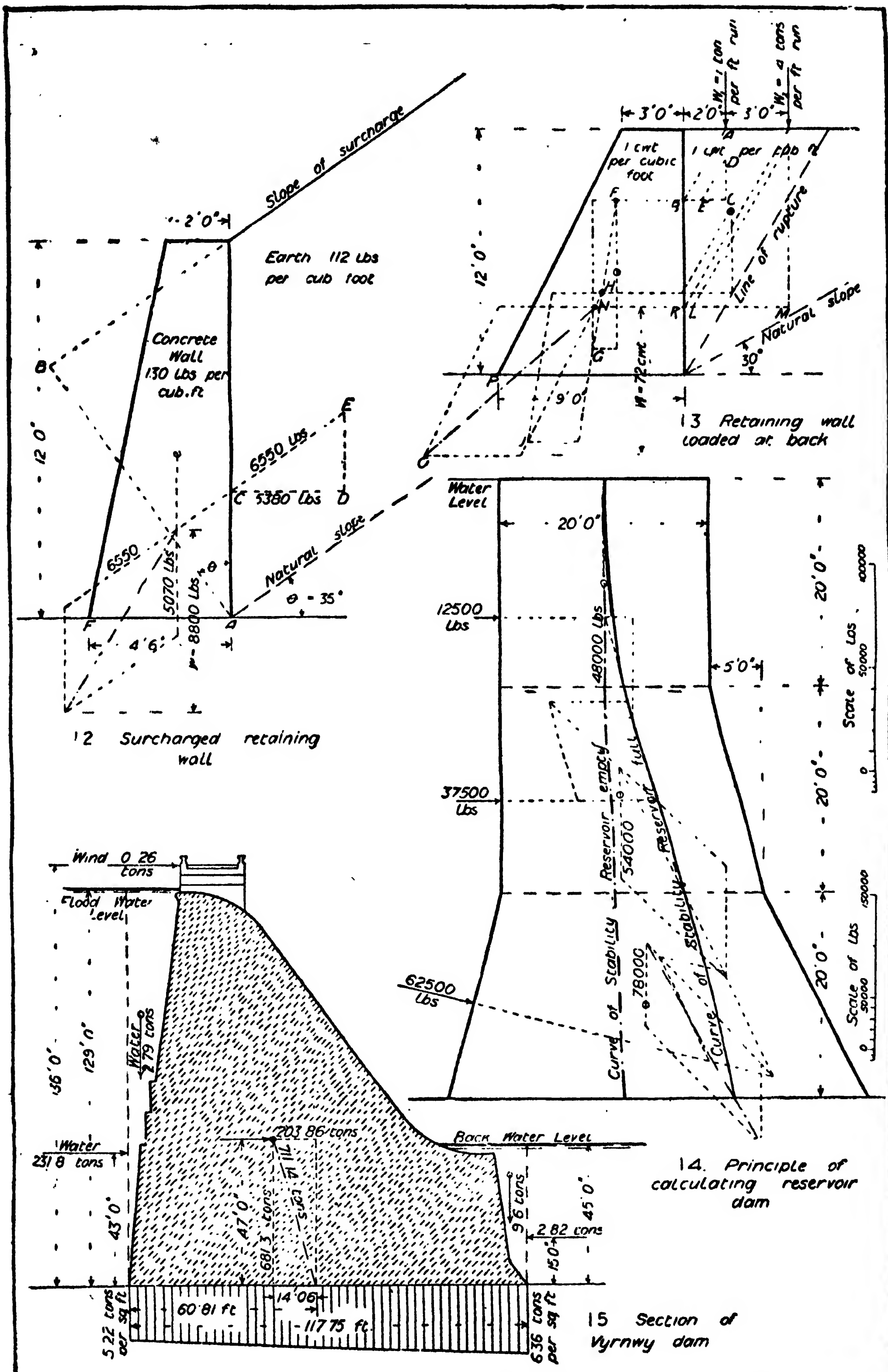
$$\frac{2}{3} \cdot \frac{W}{d} = \frac{2 \times 72}{3 \times 0{\cdot}9} = \frac{144}{2{\cdot}7} = 53{\cdot}3 \text{ cwt.},$$

or, say, 2·66 tons per square foot maximum compression on the brickwork.

Reservoir Wall or Dam. When a wall has to support the pressure of water the same method of working as in **11** might be adopted, taking the natural slope as zero; but it is more usual simply to calculate the pressure normal to the back of wall at one-third the height as $\frac{1}{2}wh^2$, where w = 62·5 lb., the weight of a cubic foot of water, and h = the height of wall. For high walls the material is economised by using a curved batter, so that the resultant of thrust passes through the extremity of the middle third at every horizontal section. A dam is shown in **14** in three simple stages to illustrate the mode of working to ascertain the stability. For a plain wall with straight batter the thickness at base may be approximately seven-tenths of the height. The section of the Vyrnwy dam is shown in **15**, with particulars of the loads and thrusts. This is of special interest owing to its magnitude and the successful manner in which the whole of the works were executed.

HENRY ADAMS

A Dictionary of Technical Terms used in Civil Engineering appears at the end of the Self-Educator



12 Surcharged retaining wall

13 Retaining wall loaded at back

14. Principle of calculating reservoir dam

15 Section of Vyrnwy dam

12–15. SURCHARGED RETAINING WALLS AND RESEVOIR DAMS

A Survey from Macaulay to Stevenson, with a Glance at Some Writers of the Twentieth Century.

THE MODERN ERA OF PROSE

CARLYLE's greatest contemporary as an essayist and historian was THOMAS BABINGTON MACAULAY (b. 1800; d. 1859). Unlike Carlyle, Macaulay did not confine his labours to the desk. He was a public official and a member of Parliament as well as a man of letters. After a careful education, he became famous at the age of twenty-five as the writer of an essay on Milton in the "Edinburgh Review." In this Review all his best-known "Essays" appeared, if we except the biographies of Atterbury, Bunyan, Goldsmith, Johnson, and Pitt, which were contributed to the "Encyclopædia Britannica." The "Essays" are rich in applied knowledge, drawn from the exceptionally retentive memory of an omnivorous reader. The judgments they contain, where these are not affected by the author's Whig sympathies, are usually sound. For a parallel to their diversity of subject-matter we must go to Landor's "Conversations."

The Brilliancy of Macaulay. But Macaulay was essentially a popular writer, one whose purpose was to think for his readers and to leave nothing to chance. Whole generations may be said to have been nurtured on his writings. His influence will always be considerable both as a stylist and as a historian, though he will require to be edited wi h some care. The "Essays" on Warren Hastings and John Hampden, for example, are both based on inaccurate data. His great quality is clearness of diction, which he shares with Cobbett; but his use of a succession of short sentences, while flattering to the eye, is not invariably acceptable to the ear. He is apt to overburden his theme with detail. His use of antitheses is responsible for much deplorably ineffective imitation. He remains, withal, a brilliant writer, but, being brilliant, is hard. What he gains in glitter he misses in emotion; he does not delve very deeply into the heart of things; but without his aid many men and women of average insight and ability would never have been able to see so far or so well as they have seen.

In this connection the educative value of Macaulay's writings cannot easily be exaggerated; it may be more easily satirised. In the realm of prose his relation to Carlyle is that of Tennyson to Browning in the realm of poetry. It is curious to notice that, in judging Scott, both Carlyle and Macaulay erred, if at all, on the side of severity; but it is useful to remember that neither of them had the "Journal" before him. Macaulay has been infinitely happier in his biographer than was Carlyle; the fine tribute of his nephew, Sir George Otto Trevelyan, to his memory reveals to us a strong family affection for any sign of which the reader might search the "Essays" in vain.

Specimen of Macaulay's Style. We give as a sample of Macaulay's style a famous passage from the "Essay" on Von Ranke (1840):

"The Catholic Church is still sending forth to the farthest ends of the world missionaries as zealous as those who landed in Kent with Augustin, and still confronting hostile kings with the same spirit with which she confronted Attila. The number of her children is greater than in any former age. Her acquisitions in the New World have more than compensated for what she has lost in the Old. Her spiritual ascendency extends over the vast countries which lie between the plains of the Missouri and Cape Horn, countries which, a century hence, may not improbably contain a population as large as that which now inhabits Europe. . . . She saw the commencement of all the governments and of all the ecclesiastical establishments that now exist in the world; and we feel no assurance that she is not destined to see the end of them all. She was great and respected before the Saxon had set foot on Britain, before the Frank had passed the Rhine, when Grecian eloquence still flourished in Antioch, when idols were still worshipped in the temple of Mecca. And she may still exist in undiminished vigour when some traveller from New Zealand shall, in the midst of a vast solitude, take his stand on a broken arch of London Bridge to sketch the ruins of St. Paul's."

Carlyle's Contemporaries. JOHN STERLING (b. 1806; d. 1844) was greater as a literary influence than as a writer. But he was a valued contributor to several reviews; his "Essays and Tales" were edited by his former tutor, J. C. Hare, and he was for a time proprietor and editor of the "Athenæum," and founder of that once famous literary circle the Sterling Club. RICHARD CHENEVIX TRENCH (b. 1807; d. 1886) was an indefatigable philologist, whose "Study of Words" and other kindred books have proved worthy of bringing up to date. WILLIAM SPALDING (b. 1809; d. 1859) was a contributor of Shakespearean articles to the "Edinburgh," and wrote a small "History of English Literature." EDWARD FITZGERALD, a member of the Sterling circle, is, as a prose writer, best represented by his "Euphranor: A Dialogue on Youth," and his wonderful letters. JOHN BROWN (b. 1810; d. 1882), the author of some delightful essays entitled "Horæ Subsecivæ" (Leisure Hours). He is easily among the masters of English prose, and his little sheaf of writings is one of the most precious in our harvest of Literature.

JOHN FORSTER (b. 1812; d. 1876) wrote many admirable essays in history and biography. His "Life of Dickens" remains the most popular of his works. Sir ARTHUR HELPS (b. 1813; d.

1875) wrote a series of essays and dialogues entitled "Friends in Council," which have lost favour. He edited the speeches and addresses of the Prince Consort and Queen Victoria's "Leaves from a Journal of Our Life in the Highlands." To RICHARD WILLIAM CHURCH (b. 1815; d. 1890) we owe a standard criticism of Dante and able studies of Spencer and Bacon in the "English Men of Letters." MARK PATTISON (b. 1813; d. 1884), another contributor (of the volume on Milton) to this series, wrote a "Life of Isaac Casaubon," a well-known classical scholar who lived in the sixteenth century. Compared with his scholarship, Pattison's output was singularly limited, but his life-story is a fascinating if sad one. He is mercilessly caricatured as Mr. Casaubon in "George Eliot's" "Middlemarch." Sir CHARLES GAVAN DUFFY (b. 1816; d. 1903) wrote a charming work on "The Ballad Poetry of Ireland." GEORGE HENRY LEWES (b. 1817; d. 1878) founded and edited the "Fortnightly Review," and did not a little to popularise the study of philosophy and science.

Froude and Others. The name of JAMES ANTHONY FROUDE (b. 1818; d. 1894) is the centre of a perfect whirlwind of controversy. As a partisan he excelled Macaulay. His contentious character colours all he wrote, but his "Nemesis of Faith," "Oceana," "Short Studies on Great Subjects," and his "Lectures" possess a positive, if all but indefinable, fascination for most readers. He wrote with a sincerity that was almost Carlylean, and his thought frequently soars to heights of undeniable eloquence. GEORGE BRIMLEY (b. 1819; d. 1857) was a critic whose anonymous contributions to "Fraser's" and the "Spectator" thoroughly merited their republication in collected form. His studies of Tennyson, Wordsworth, Patmore, Carlyle, Thackeray, Lytton, Dickens, Kingsley, Wilson, justify a place for him in literary history.

RICHARD HOLT HUTTON (b. 1826; d. 1897) established, with MEREDITH WHITE TOWNSEND (b. 1831; d. 1911), the modern reputation of the "Spectator" as a review of public life and literature. Hutton's contributions embraced politics, literature, and theology, and Townsend, who had lived long in India, was an authority on Asiatic questions. WALTER BAGEHOT (b. 1826; d. 1877) wrote brilliantly alike on economics and politics, and his literary criticisms have a stimulating individuality. HENRY MORLEY (b. 1829; d. 1900) did excellent work by his survey of English literature for students, and his cheap republication of English literary masterpieces. SIR JAMES FITZJAMES STEPHEN (b. 1829; d. 1894) was a brilliant journalist and critic before he became a judge and writer on law. SIR LESLIE STEPHEN (b. 1832; d. 1904), brother of Sir James, was a delightful bookman—see his "Hours in a Library"—a fascinating Alpinist—see his "Playground of Europe"—and the editor of nearly the whole of the first issue of the invaluable "Dictionary of National Biography." WILLIAM MINTO (b. 1845; d. 1893) wrote much sound literary criticism for the "Encyclopædia Britannica"; and WILLIAM ERNEST HENLEY (b. 1849; d. 1903) was a critic, as well as poet, of tempestuous individuality and bold initiative.

The Influence of Ruskin. JOHN RUSKIN (b. 1819; d. 1900) proved a great social force as well as a great critic. Perhaps his paramount service in criticism was his defence of Turner. He imparted an incalculable impetus to the raising of the standard of labour; whatever nature of labour it may be, it can hardly be regarded without some respect by anyone who has come under the influence of Ruskin's teaching. Like Carlyle, and, in a lesser degree, like Froude, Ruskin gloried in the power of imparting and inspiring enthusiasm. He sought after the truth with all the ardour of Carlyle, and the student of his works will witness with mingled feelings how, time after time, he was compelled by his own discoveries to relinquish positions he at one time thought to be unassailable.

Ruskin was the embodiment of the spirit of reverence, and a high priest of the temple of beauty. He has opened our eyes to the infinite variety and charm of external Nature, and even the clouds have a different meaning to us since Ruskin wrote about them. His style glows with rich colour, and is full of musical sweetness. It is impregnated with the influence of Bible study, an influence which, however, can be realised only by those whose knowledge of the Bible corresponds in some measure to Ruskin's own intimate grasp of it.

What Arnold Taught Us. MATTHEW ARNOLD (b. 1822; d. 1888), in prose, combined social with literary criticism. He foretold the fall of the aristocracy, and distrusted the middle classes, but much that has been written and said concerning his "contempt for unintellectual people" is unjustified, and caused him no small amount of disquiet, as his "Letters"—especially the epistle written to his mother in 1868—testify. As a writer, he had much in common with Sainte-Beuve, perhaps the greatest literary critic of the nineteenth century, his standpoint in regard to art and letters being in many respects more French than English. First and foremost, he was a scholar, and valued scholarship highly. His "Essays in Criticism," "Culture and Anarchy," "Literature and Dogma," and an earlier work, "On Translating Homer," are his most widely read books, but there is no complete edition of his prose writings, and no definite biography has been written of him.

Mr. G. W. E. Russell, in his very able but unsatisfying monograph, sums up the indebtedness of his friends and followers to Matthew Arnold in these words: "We who were happy enough to fall under his personal influence can never overstate what we owe to his genius and his sympathy. He showed us the highest ideal of character and conduct. He taught us the science of good citizenship. He so interpreted Nature that we knew her as we had never known her before. He was our fascinating and unfailing guide in the tangled paradise of literature. And while for all this we bless his memory, we claim for him the praise of having enlarged the boundaries of

the Christian Kingdom by making the lives of men sweeter, brighter, and more humane."

Walter Pater and Others. Eminent among the other critics who lent distinction to English letters in the latter part of the nineteenth century was WALTER HORATIO PATER (b. 1839; d. 1894), whose exclusiveness was akin to that which so long kept Matthew Arnold aloof from the average reader, and whose "Sketches in the History of the Renaissance," "Imaginary Portraits," and "Appreciations" are marked by an exotic beauty of style, refinement of taste, breadth of culture, and keenness of insight. Into the point of view of Walter Pater it is not here necessary to enter, but this must come into consideration where the permanent value of his work is considered. A similar remark is called for in regard to the writings of another and a less "precious" hedonist, JOHN ADDINGTON SYMONDS (b. 1840; d. 1893), who also helped to bring the bright side of the Renaissance, as well as that of Elizabethan England, before English readers. PHILIP GILBERT HAMERTON (b. 1834; d. 1894) wrote a series of letters on "The Intellectual Life" which literary aspirants should not neglect. Young people especially should read "The Ideal Life," by HENRY DRUMMOND (b. 1851; d. 1897), author of "Natural Law in the Spiritual World,' whose "Life," by George Adam Smith, is one of the finest of modern biographies.

Great Names in the Modern School. Among critics whose work will have a lasting value may be mentioned DAVID MASSON (b. 1822; d. 1907), the biographer of Milton, for thirty years Professor of English Literature in Edinburgh University. His writings on English writers—as, for example, De Quincey and Ben Jonson—have added distinctly to the sum of human knowledge.

ALGERNON CHARLES SWINBURNE (b. 1837; d. 1909), the poet, wrote much incidental criticism, including studies of Shakespeare, Chapman, Ben Jonson, and Charlotte Brontë. Though his fervour became lyrical, it often expressed fine insight. EDWARD DOWDEN (b. 1843; d. 1913) was a student of French and English literature, and his works on Shakespeare and Shelley in particular have become classic. JOHN CHURTON COLLINS (b. 1848; d. 1908), who at the time of his death was Professor of English Literature at Birmingham University, not only published valuable studies in poetry and criticism, but strenuously advocated a greater prominence for the study of English literature at the universities. ANDREW LANG (b. 1844; d. 1912) was one of the ripest scholars and most versatile among the men of letters of his time. His work included unsurpassed translation, practised verse, serious history, biography, fiction, and a very wide range of literary criticism. Mythology was his foible. Another critic of varied talent and remarkable industry was WILLIAM SHARP (b. 1856; d. 1906), and there is literary charm in the essays of RICHARD JEFFERIES (b. 1848; d. 1887), while a fine quality marks the essays of ALFRED AINGER (b. 1837; d. 1904). The lifework of RICHARD GARNETT (b. 1835; d. 1906), biographer and literary historian, should be studied as exemplifying the possibilities of self-help and the value of adopting a wide as against a narrow and "specialist" interest in literature.

Other Leading Critics and Writers. Work of serious value was done by WILLIAM RATHBONE GREG (b. 1809; d. 1881), whose pessimistic spirit found voice in attractive literary forms; GOLDWIN SMITH (b. 1823; d. 1910), a philosopher and critic, as well as a historian; SIR ALFRED LYALL (b. 1835; d. 1911), whose Asiatic studies were marked by distinction of thought and feeling; LORD AVEBURY (b. 1834; d. 1913), who proved that a strenuous business life is no bar to the pursuit of literature and science; SIR M. E. GRANT DUFF (b. 1829; d. 1906), the diarist; SIR THEODORE MARTIN (b. 1816; d. 1909), whose "Life of the Prince Consort" and "Memoir of Helena Faucit, Lady Martin," are full of human interest; JUSTIN MCCARTHY (b. 1830; d. 1912), whose "History of Our Own Times" and other historical sketches commended themselves even to his political opponents; ROBERT FLINT (b. 1838; d. 1910), a professor who dealt boldly with the thought of his time, theological and political; SAMUEL HENRY BUTCHER (b. 1850; d. 1910), a scholar with literary gifts; EDWARD CAIRD (b. 1835; d. 1908), the successor of Jowett at Balliol, and a notable thinker and economist; and FREDERICK JAMES FURNIVALL (b. 1825; d. 1910), a Shakespearean scholar and editor of distinction.

The Men of Today in Literature. Positions of exceptional distinction must be assigned to AUGUSTINE BIRRELL (b. 1850), whose success in Parliament has only been regretted because it has deprived the world of further delightful essays; SIR ARTHUR QUILLER-COUCH (b. 1863), who to success in fiction and as a critic has added great popularity in the Chair of Literature at Cambridge; and to FREDERIC HARRISON (b. 1831), who may be said to have given to Positivism what was meant for literary history, but who has been a stalwart in the battle for the extension of university education. His "Choice of Books and other Literary Pieces" and "Early Victorian Literature" claim special note in these pages.

GEORGE EDWARD BATEMAN SAINTSBURY (b. 1845), originally assistant-master of Manchester Grammar School, and, like Masson, one-time editor of "Macmillan's Magazine," and his successor at Edinburgh University, is the possessor of a style as polyglot as his reading. He is one of the greatest of living critics, the author of innumerable handbooks on English and French literature, and of valuable biographies of Dryden, Scott, and Matthew Arnold. THEODORE WATTS-DUNTON (b. 1836) abandoned the study of natural history and the law for the fields of fiction and criticism as well as poetry; in criticism he has been one of the forces of the last century. His "Studies of Shakespeare" and "The Renascence of Wonder" are notable productions, but for some of his most remarkable work the student must turn to the pages of the "Examiner," the "Athenæum," the

"Encyclopædia Britannica," "Chambers's Encyclopædia," and the leading reviews. EDMUND GOSSE (b. 1849) has given us Lives of Donne, Gray, Jeremy Taylor, Coventry Patmore, and Sir Thomas Browne, a charming book of "French Profiles," and luminous studies of the seventeenth and eighteenth centuries. With Mr. Gosse must be associated AUSTIN DOBSON (b. 1840), whose "Eighteenth Century Vignettes" and studies of Steele, Goldsmith, Walpole, Hogarth, Richardson, and Fanny Burney possess much of the quality of sincerity, scholarship, and feeling which characterise his poems. STOPFORD AUGUSTUS BROOKE (b. 1832) has made generations of young students his debtor by a consummate "Primer of English Literature." His more bulky works include a History of English Poetry to the Accession of Ælfred, "English Literature from the Beginning to the Norman Conquest," "English Literature from A.D. 670 to A.D. 1832," a volume of vividly written studies "On Ten Plays of Shakespeare," the "Life and Letters of Frederick William Robertson," and studies of the poems of both Tennyson and Browning.

Professors of Literature and Poetry. "Shakespearean Tragedy," by ANDREW CECIL BRADLEY (b. 1851), who has been Professor of English Poetry at Oxford, should be read. A former occupant of this honourable Chair, WILLIAM JOHN COURTHOPE (b. 1842), has published an exhaustive "History of English Poetry" in six large volumes. Mr. Courthope, whose aim has been to "use the facts of political and social history as keys to the poet's meaning, and to make poetry clothe with life and character the dry record of external facts," wrote in 1885 a suggestive series of essays on "The Liberal Movement in English Literature." His Oxford lectures, "Life in Poetry: Law in Taste," his admirable monograph on Addison, and his "Life of Pope," written for his standard edition of Pope's works, are of permanent value.

SIR WALTER RALEIGH, who is Professor of English Literature at Oxford, is the author of several works which may be commended for their vigour and the brilliant imagery of their style as well as for their high educational value. We refer to the "English Voyages of the Sixteenth Century,' his studies of Stevenson, Milton, and Wordsworth, a charming book on "Style," and his handbook to "The English Novel." Sir FREDERICK WEDMORE (b. 1844) is an acute critic of letters as well as of art—witness his "Life of Balzac."

Reference must be also made to the chatty books by GEORGE WILLIAM ERSKINE RUSSELL (b. 1853), and to the literary and philosophical reviews of WILLIAM L. COURTNEY (b. 1850), a worthy successor to G. H. Lewes as editor of the "Fortnightly Review"; to VIOLET PAGET ("Vernon Lee") (b. 1856), whose "Renaissance Essays" are full of charm; ALICE MEYNELL, whose essays, "The Rhythm of Life," were at once hailed as "classical"; M. E. BETHAM-EDWARDS (b. 1836), who has done so much to explain French life and thought to English readers; SIR W. ROBERTSON NICOLL (b. 1851), whose work as editor, essayist, critic, and theologian is informed with an individual style, genuine love of books, knowledge of life, and scholarship; H. G. WELLS (b. 1866), a novelist by compulsion, whose "Mankind in the Making" and "A Modern Utopia" prove him to be a psychologist by nature; WILLIAM ROMAINE PATERSON ("Benjamin Swift") (b. 1871), of whom the same may be said by virtue of his remarkable essay "The Eternal Conflict"; WILLIAM HURRELL MALLOCK (b. 1849), a thoughtful student of social economics; RICHARD LE GALLIENNE (b. 1866), a true bookman, and a critic who unites sound judgment with grace of style; GILBERT KEITH CHESTERTON (b. 1873), beneath whose love of paradox is discernible the light of a far-seeing intellect; J. G. FRAZER, of "Golden Bough" fame; R. SEEBOHM ROWNTREE, who has written on social economics; C. W. SALEEBY, a pioneer of eugenics; CLEMENT KING SHORTER (b. 1858), author of "Charlotte Brontë and her Circle" and "Sixty Years of Victorian Literature": HENRY HAVELOCK ELLIS (b. 1859); EDWARD CARPENTER (b. 1844); SIDNEY WEBB (b. 1859); and SIR LAURENCE GOMME (b. 1853).

ROBERT LOUIS STEVENSON (b. 1850; d. 1894) has been described as "the happiest master of vagabond discourse in the whole of the nineteenth century." He travelled directly for his health's sake; the indirect benefit of his travels to English literature it is difficult to over-estimate. He began as an essayist, and his chief prose works, apart from fiction, are "An Inland Voyage," "Travels with a Donkey in the Cevennes," "Virginibus Puerisque," "Familiar Studies of Men and Books," "Memories and Portraits," and "Across the Plains." He won fame first as a writer of romance, and then, turning to the hitherto almost neglected prose essays, the public found in them the most intimate and delightful self-revelations of a winning personality.

The Prose Style of "R. L. S." Stevenson's style is the outcome of infinite labour; it is not a style that could be copied with profit, but the young writer with aspirations should read all the books we have named. "In an age of journalism," says Professor Raleigh, "of barren repetition and fruitless expatiation, it is high praise to give even of a great prose writer to say of him that he never proses. This praise is due to Stevenson; his chisel, which rang in the workshop of many masters, was always wielded under the direction of a marvellously quick eye, by a hand that gathered strength and confidence every year. He has left no slovenly work, none that has not an inimitable distinction, and the charm of expression that belongs only to a rare spirit. If the question be raised of his eventful place in the great hierarchy of English writers, it is enough to say that the tribunal that shall try his claims is not yet in session; when the time comes he will be summoned to the bar, not with the array of contemporaries whose names a foolish public linked to his, but with the chief prose writers of the century, few of whom can face the trial with less to extenuate and less to conceal."

We have now noted most of the important prose-writers of the nineteenth century, but there remain a good many names which call at least for mention, and, without endeavouring to compile a complete list of these, we shall indicate as many as possible in the bibliographical summary with which we bring this section of our study to a close.

Notable Books of Biography. The works of some of the chief biographers and historians of the nineteenth century have been referred to already. In the field of biography the following books are generally admitted to be of permanent value: Southey's "Nelson"; Lockhart's "Scott"; Lewes's "Goethe"; Carlyle's "Sterling"; Froude's "Carlyle"; Stanley's "Arnold"; Forster's "Dickens"; Milman's "Gibbon"; Mrs. Gaskell's "Charlotte Brontë"; Trevelyan's "Macaulay"; Masson's "Milton"; Spedding's "Bacon"; Sidney Lee's "Shakespeare"; Gifford's "Ben Jonson"; Cross's "George Eliot"; Dowden's "Shelley"; Martin's "Prince Consort"; J. W. Mackail's "William Morris"; John Morley's "Voltaire," "Rousseau," and "Gladstone"; Lord Tennyson's "Life" of his father; and Sir E. T. Cook's "Life of Ruskin."

History. History bulks largely in the period under review. The chief works on English history are Hallam's "Constitutional History of England"; Lingard's "History of England to 1688"; Macaulay's "History of England from the Accession of James II."; Carlyle's "Cromwell's Letters and Speeches"; Froude's "From the Fall of Wolsey to the Defeat of the Armada"; Green's "Short History" (the best of its kind); Gardiner's "History of England, 1603-1642," "History of the Great Civil War," "History of the Commonwealth and Protectorate," and "Oliver Cromwell"; Freeman's "History of the Norman Conquest," "Growth of the English Constitution," and "The Reign of William Rufus"; Stubbs's "Constitutional History of England"; F. W. Maitland's "Lectures on Constitutional History"; Sharon Turner's "History of the Anglo-Saxons"; Seeley's "The Expansion of England"; Buckle's unfinished "History of Civilisation"; Lecky's "History of England in the Eighteenth Century," and other works on European history; Seebohm's "The Oxford Reformers of 1498," "Era of the Protestant Revolution," "The English Village Community," and "Tribal System in Wales"; Creighton's "Simon de Montfort," "History of the Papacy during the Reformation Period," "Queen Elizabeth," and a charming little manual on "The Age of Elizabeth"; Palgrave's "Rise and Progress of the English Commonwealth"; C. H. Firth's several books on the Commonwealth; Brewer's "Henry VIII.," and May's "Constitutional History of England, 1760-1863."

In recent years the tendency has been towards the careful study of limited periods by specialists, as in the "Cambridge Modern History," planned by Lord Acton, and edited by A. W. Ward, G. W. Prothero, and Stanley Leathes; and the "Cambridge Mediæval History," edited by J. B. Bury. Similar "Periods of European History" have been published. Literature has been dealt with in the same way in the admirable "Cambridge History of English Literature," edited by A. W. Ward and A. R. Waller, and in the series of "Handbooks of English Literature," edited by J. W. Hales. In some cases a special line of historical development has been followed, as in Professor James Mackinnon's eloquent "History of Modern Liberty."

In addition must be noted Mill's "History of British India"; Maine's "Village Communities," and "Popular Government"; Tytler's "History of Scotland"; Burton's "History of Scotland"; Coxe's "House of Austria"; Grant Duff's "History of the Mahrattas"; Elphinstone's "History of India" and "Rise of the British Power in the East"; Kaye's "Histories of the Afghan and Sepoy Wars"; Kinglake's "Crimea"; Mitford's, Thirlwall's, Grote's, and Finlay's Histories of Greece; Thomas Arnold's "History of Rome"; Alison's "History of Europe"; Merivale's "History of the Romans under the Empire"; Milman's "History of Latin Christianity"; William Napier's "History of the Peninsular War"; Bryce's "American Commonwealth"; and Agnes Strickland's "Lives" of the Queens of England and Scotland.

Theology and Philosophy. Students of philosophy and theology are recommended to refer to the following names in any good biographical dictionary: Jeremy Bentham, Sir William Hamilton, Henry Mansel, Richard Whately, William Whewell, David Ricardo, J. R. McCulloch, John Stuart Mill, Richard Owen, Charles Darwin, Herbert Spencer, Thomas Henry Huxley, W. A. Butler, Thomas Hill Green, G. H. Lewes, Sir James Mackintosh, Thomas Malthus, John Keble, Edward Bouverie Pusey, Richard William Church, John Henry Newman (whose style is especially important to students of the language), W. E. Gladstone, Arthur Penrhyn Stanley, Thomas Chalmers, John William Burgon, Richard Hurrell Froude, Edward Irving, Henry Parry Liddon, Joseph Lightfoot, Frederick Denison Maurice, James Mozley, James Craigie Robertson, Frederick William Robertson, Richard Chenevix Trench, John Tulloch, Christopher Wordsworth, William Wilberforce, Charles Haddon Spurgeon, R. W. Dale, and James Martineau.

Travel and Science. The records of travel and exploration are brightened by such names as those of Austen Layard, Samuel Baker, David Livingstone, John Pinkerton, Charles Waterton, George Borrow, Richard Burton, Edward Lane, Sir F. E. Younghusband, Sir H. H. Johnston, Sir W. M. Conway, George Warrington Steevens, the brilliant war-correspondent, and Sir Frederick Treves. Some mention must also be made of the scientific studies of Max Müller, Charles Lyell, Herbert Spencer, John Tyndall, Thomas Huxley, Richard A. Proctor, and Sir Robert Ball.

J. A. HAMMERTON

The Pay and Prospects of Intermediate, Second Division, and Assistant Clerks. Messengers. Boy Clerks.

CLERKSHIPS AND MINOR POSTS

First Class clerks, as we have seen, form the foremost grade of the general civil staff—that is, of those employed not in a particular department only but throughout the service. In this chapter we review in turn each of the remaining appointments on the general staff.

These posts may be arranged in order of value, thus: "Intermediate" Officer; Second Division Clerk; Assistant Clerk or Abstractor; Officekeeper and Messenger; Boy Clerk.

Intermediate Appointments. The old reproach against the national service, that it held no place for the lad from a public school, has been removed by the creation of a special grade of Intermediate examinations—so called because they admit to posts inferior to Class I. clerkships, but distinctly better than the Second Division or the Customs and Excise. The age limits for these contests—18 and 19½—are intended expressly to suit candidates who have recently left school, and the standard of the papers set is, roughly, that of the sixth form.

The examination, which is held twice yearly, consists of three parts, or classes. Every competitor must take Class I., comprising mathematics—arithmetic, geometry, algebra, and trigonometry—English composition and précis writing, and a "General Paper." This last is based on history, but is designed as a test of general intelligence and education. An explanation of précis writing appears on the next page. From the other two classes the candidate may select papers—one, at least, being a language—up to a maximum of 10,000 marks. In Class II. the subjects, each carrying 2000 marks, are as follow: Higher mathematics, French, German, Latin, Greek, English history, European history, chemistry, and physics. Class III. consists of more advanced papers in the first five of the subjects mentioned, 4000 marks being allotted to each. Candidates' studies may thus either cover a wide field or be restricted to a special mastery of three or four subjects.

The Intermediate posts, although mainly clerical, are of various kinds and of somewhat unequal value. They include the rank of Assistant Surveyor of Taxes, Examiner in the Exchequer and Audit Department, and clerkships in some fourteen of the Government offices. In every instance the initial salary is £100, advancing after two years from £120 by £10 yearly to £200, and thence by £15 to £350. Beyond that figure, promotion is uncertain, the prospects varying in different offices, but there are excellent chances of £450 or £500 at least, and further possibilities up to £700, and more. To youths with a good education, as well as to studious members of the subordinate ranks of the service, the Intermediate examinations undoubtedly offer a promising career.

Second Division Clerkships. Like the "non-commissioned man" of Kipling's ballad, the Second Division clerk may fairly claim to be "the backbone of the service." While not enjoying anything like the position or prospects of the Class I. clerk—who is the commissioned officer of the civilian army—he holds acknowledged rank in the public service, is entrusted with somewhat responsible duties, and commands the respectful consideration of his subordinates. Moreover, he has moderate chances of obtaining commissioned rank. In two important respects, however, the analogy fails. As a rule, the Second Division clerk is not promoted to that grade, but is appointed to it directly; and his normal duty is not the instruction or supervision of others, but an executive task of his own.

Second Division clerks are employed in 62 Government offices, and numbered 3960 in all when last scheduled. Of this total, 536 were then engaged in Dublin, only 202 at Edinburgh, and practically all the remainder in London—that colossal department the General Post Office absorbing over 900, or about one-fourth of the whole force.

Duties, Pay, and Prospects. Except for copying and merely mechanical duties, a large proportion of the clerical work of the service is entrusted to these officers. Nominally, their function is restricted to "routine work"; and in the Post Office and certain other branches the official phrase is a fairly exact description. In many departments, however, they are occupied with involved or confidential tasks to which that definition does not apply at all, and for which their pay is certainly inadequate. In this way, on the other hand, claims to promotion are often established. "The special character of the duties performed" is the reason most frequently assigned for such advancements.

The Second Division clerk may be required to perform temporary duty before receiving a permanent appointment, and during the first year of his service on the establishment is upon probation. His hours of duty are seven daily, with a half-holiday weekly or on alternate Saturdays, according to the custom in individual offices. In addition to the usual public holidays, the annual leave for clerks of less than five years' service is fourteen working days, and for their seniors twenty-one, and afterwards twenty-four working days.

Second Division clerks are remunerated as follows: Starting at £70 a year, they advance by £7 10s. annually to £130, afterwards progressing by £10 increments to £300.

As an incentive to good work, a service regulation provides that a clerk of not less than six years' standing may receive, as a reward for

exceptional merit, a special increase of salary not to exceed four annual increments.

Apart from such individual advancements the progress of the Second Division clerk is certainly slow. A simple calculation shows that in the ordinary way his maximum salary is reached only after 25 years. Yet the certainty of his position, its steadily advancing stipend, and the fair prospects it affords of promotion to the better-paid posts, combine to make Second Division clerkships among the most eagerly contested appointments in the national service.

Promotion. The regulations provide that after eight years' service these officers are eligible for advancement to the First Class. Hitherto, however, such promotions have been sparingly made, averaging only some 30 cases yearly. On the other hand, a number of less valuable staff posts, with salaries ranging from £400 to £750 a year, are reserved for meritorious members of the Second Division. About 90 promotions of this character take place annually.

The proportion of these higher positions differs greatly in the various branches. The Colonial Office, Home Office, and other great administrative departments afford many such openings, but in the Post Office they are not at all common. Successful competitors are usually allowed, in order of merit, a certain—or rather, an uncertain—range of choice among the numerous offices. But their selections are necessarily often disregarded, the appointments being determined mainly by the occurrence of vacancies. Candidates should therefore recognise clearly at the outset the possibility that they may find themselves, through no fault of their own, practically debarred from advancing beyond the £300 yearly which is the maximum of the Second Division.

But an ambitious officer may employ his leisure in studying for a better-paid appointment. For this task he will be peculiarly fitted, not only by his previous training, but also by the valuable extension of age allowed (as explained on page 1920) to candidates already in the national service. For Intermediate posts this extension is limited to an extra year.

The Examination. Open competitions for Second Division clerkships are held yearly, the number of appointments offered at each varying between 100 and 300, according to the needs of the departments. Candidates must be between 17 and 20 years of age, but those who have served for two years or more in a Government office may enter until 22 years old.

The educational scope of these contests corresponds generally with that of an ordinary second-grade school. There are, in addition, a few special Civil Service subjects such as few schoolmasters teach. They comprise copying manuscript, précis, and shorthand. For the first of these exercises the candidate is given a lithographed copy of a badly written document, so altered and blurred in parts as to be almost undecipherable. Of this he is required to make, in the half-hour at his disposal, a neat and clearly legible transcript, with as few erasures as possible. Difficult passages are best deciphered by a fairly rapid perusal, as in a very illegible hand the context, rather than a minute study of individual characters, affords the readiest solution to the puzzle.

The précis subject is more difficult. A number of printed letters and papers relating to some official matter are handed to the competitor. After reading these he must write a précis or summary, in the form of a continuous narrative, of the whole correspondence, so that a perusal of the précis would place anyone in possession of all the leading features of what had passed. The merits of such a summary, in official phraseology, are: "(*a*) to include all that is important in the correspondence; (*b*) to present this in a consecutive and readable shape, expressed as distinctly as possible, and as briefly as is compatible with distinctness."

The shorthand test consists in taking down, and afterwards transcribing, passages read at three speeds—60, 80, and 100 words a minute.

"Tots." The arithmetic test in these competitions includes a special paper that merits the particular attention of candidates. This is the "tots" paper — a simple trial of speed and precision. Candidates are given a printed set of exercises in addition, having the figures arranged in horizontal columns. The *totals* of these figures have to be inserted in the form itself; hence the students' slang term "tots." Simple as the paper is, candidates who have not accustomed themselves to work accurately at top speed are certain to lose marks for errors or for failing to finish the exercise.

The full list of examination subjects for Second Division clerkships, the maximum for each, and the actual marks obtained by the first and last successful candidates at a recent contest, are shown in the table on page 2173. It should be noticed that, of the 12 papers, only 8 may be taken, including not more than two languages; and further that, although no subject is obligatory, the competition is so keen that a candidate who took less than the full number permitted would not have the slightest chance of success. At this examination 1800 students competed for only 150 places—an abnormally high proportion of candidates to vacancies.

Service Marks. A curious feature of these competitions is the allowance of special marks, proportionate to their term of service, to candidates who have been employed in Government offices as boy clerks. Thus 40 "service marks" are given for a year's service, and the maximum of 80 is secured by two or more years' employment. These form very substantial additions to the examination total. For instance, in the competition to which our table of marks relates, no fewer than 52 successful candidates were aided by service marks.

Assistant Clerkships. The post of assistant clerk or abstractor offers few attractions beyond permanent employment and a slowly progressive income. Its mechanical duties are repaid by a salary less than that of any

other officer on the permanent clerical staff. On the other hand, this grade is recruited wholly from the ranks of former boy clerks who have lacked the energy, the ability or fortune to secure better positions in the Second Division or elsewhere. The pay of assistant clerks, beginning at £45 a year, rises by £5 annually to £85, and thence by £7 10s. to £150. They are allowed 14 days' annual leave, and after ten years' service this becomes 18 days. They may be promoted to the Second Division, on the ground of special merit, after not less than six years' duty, and a considerable proportion of the total number are so promoted, in fact, but beyond this their prospects of advancement are of the scantiest.

EXAMINATION FOR SECOND DIVISION CLERKSHIPS

							THREE ONLY, ONE AT LEAST BEING A LANGUAGE							
							NOT MORE THAN TWO							
Order of Merit.	Service Marks.	Handwriting.	Copying MS.	English (with Précis).	Arithmetic.	Elementary Mathematics.	Latin.	French.	German.	Bookkeeping and Shorthand.	History and Geography.	Further Mathematics.	Science (Physics and Chemistry).	TOTAL.
Max.	- -	400	200	800	400	400	400	400	400	400	400	400	400	3400
1	—	380	200	530	368	385	330	292	—	—	—	332	—	2817
150	—	367	168	480	347	270	·	291	224	—	—	233	·	2380

Examinations. Examinations for assistant clerkships are held twice a year, usually in February and July. Candidates must be between 17 and 18 years of age on January 1st or July 1st of the year in which they compete, and must have actually served as boy clerks for six months at least. The subjects of examination are five in number—namely: 1. English composition (including handwriting and spelling). 2. Arithmetic (to vulgar and decimal fractions). 3. Digesting returns. 4. Précis and indexing. 5. Shorthand or bookkeeping.

Indexing. For this test, as in précis, a number of official letters is handed to each candidate. From these he must prepare an index giving the date of each document, the persons between whom it passed, and a brief, clear statement of its subject-matter, taking care to omit from the summary mere side-issues and unimportant details in the documents. A "wrinkle" worth noting is that in official correspondence an admirable summary of a letter may often be found in the reply to it.

Digesting Returns into Summaries. This quaintly named subject is a simple test of the clerkly qualities of neatness, care, and accuracy of calculation. Candidates are required to rule a form of statistical table like that given in their examination papers, to insert the various column headings, and finally to fill in the columns from printed particulars supplied. The task is never one of mere transcription, but involves always some rearrangement and mathematical work, such as the calculation of percentages, the substitution of kilogrammes for English weights, or the conversion of pounds sterling into marks or francs.

No special difficulty is presented by these two exercises, yet in each case some preliminary practice is essential in order to complete either paper within the allotted time and to avoid mistakes; for as they are tests of exactness, every mistake, even although corrected, involves a loss of marks. Elementary as they are, the student cannot afford to neglect them. He may generally ensure sufficient practice in them by attending for a term or so one of the day or evening classes for the Civil Service to be found in almost every town.

Competitors whose total marks do not indicate "a competent amount of general proficiency" are disqualified from receiving appointments. This standard has latterly been fixed at 1000 marks in a maximum of 1900.

At each examination about 100 vacancies are contested by three or four times that number of aspirants. As one-third of these, however, usually fail to attain the qualifying standard of marks, the *effective* competition is seldom much in excess of two candidates for each post. The great majority of assistant clerks are employed in London.

Poor as the appointments are in themselves, they are useful to ambitious and resolute young men who find it necessary, after serving as boy clerks, to earn a living wage while preparing for better positions. Among the present writer's official acquaintances, for instance, are two ex-abstractors, one of whom receives £550 a year, and the other £400, with a certain prospect of £650. But these are exceptional cases.

Messengers. Posts as messenger, office-keeper, housekeeper, and attendant are usually filled without competition by candidates who obtain the requisite official nomination. The right to nominate is generally vested in the head of each department, but in some instances it is in the hands of the Lords of the Treasury. The limits of age for these appointments are 21 and 35; but candidates who have served in the Army or Navy, the Metropolitan Police, or the Royal Irish Constabulary are allowed to deduct such service in reckoning their age. When a vacancy arises in a department, the

person nominated has only, as a rule, to pass a qualifying examination of an elementary character before receiving the appointment. Occasionally, however, two or three men compete for a single vacancy. The subjects of examination are writing (with copying manuscript), spelling, and arithmetic, comprising the first four rules, money, and avoirdupois weight.

Although a certain amount of influence, direct or indirect, is almost indispensable for securing a situation of this class, it is by no means necessary that the applicant should be personally known to the official who has the right to nominate. Character, ability, and a good record are as least as important. Satisfactory service in the Army or Navy is always a strong recommendation.

Rates of Pay. The salaries of subordinate officers vary a good deal, and in certain instances are augmented by "perquisites" whose value is a jealously guarded secret. The following rates may, however, be regarded as typical: Messengers and attendants begin at a figure between £65 and £80, and rise by small increments to £100, £120, or (for chief posts) £150 to £200 a year. They have also chances of advancement to the grade of officekeeper, with a salary of £100 or £150, an official residence, coal and lights, and other allowances on a liberal scale. Doorkeepers are similarly remunerated as a rule, but in important positions (as in the Houses of Parliament) they receive from £250 to £300 a year.

Boy Clerkships. The position of boy clerk in the public service is a purely temporary one, carrying no claim to superannuation, and coming to an end when the age of eighteen is reached. Nevertheless, it is in several respects a distinctly useful way of gaining a footing in the service. The number of qualified candidates has not always been equal to the demand, though very moderate marks are needed for success.

We have already referred to some of the advantages afforded to boy clerks when competing for the higher posts. Not only are assistant clerkships reserved entirely for boy clerks, past or present, but in the examinations for Second Division clerkships and for officers of Customs and Excise they may claim service marks, even though at the time of the examination they are no longer in the service. With such aids to success, a lad of ordinary ability and energy can scarcely fail to obtain a good permanent appointment, and at the worst an assistant clerkship is not to be despised.

Competitions, open to boys between 15 and 16 years of age, are held about twice yearly, a batch of some two or three hundred candidates being selected on the results of each. For the convenience of competitors the examinations are held simultaneously at London, Edinburgh, Dublin, and a number of other centres. A fee of 5s. is payable by each candidate.

Particulars of the subjects are furnished by the table below. It relates to an examination recently attended by 644 contestants, 350 of whom were placed on the register of boy clerks and given employment as occasion arose.

It is necessary only to add that the mathematics paper in these contests comprises angles, areas, and volumes, and algebra up to simple equations, and that although no subjects are obligatory, a qualifying total of half the maximum marks must be obtained.

Pay and Conditions of Service. Boy clerks are usually engaged for 39 hours weekly, and are paid during their first year 15s. a week, and afterwards 16s. Overtime work is paid for at corresponding rates. Sometimes they are employed and paid by the hour instead, the rate being 4½d. per hour during the first year, and advancing next year to 5d. As a little calculation shows, under this system of payment the nett result is practically the same as under the weekly scale. In either case continuous service is not officially guaranteed. As a matter of practice, however, the great majority of boy clerks are regularly employed. They are practically always called upon to serve in London, but recently a separate register has been instituted for appointments in Ireland, and at the last examination 20 vacancies were Irish.

Boy clerks, while employed, are paid for all public holidays, as well as during the fortnight's annual leave to which they are entitled if permanently on duty. Sick leave, up to a certain maximum, is granted on full pay. In case of enforced absence owing to infectious disease in a boy clerk's residence, he may be given the full rate of pay during his absence.

EXAMINATION FOR BOY CLERKSHIPS

Order of Merit.	Handwriting.	Orthography.	Arithmetic.	English Composition.	Copying Manuscript.	THREE MAY BE TAKEN							Total.
								TWO ONLY					
						Geography	English History.	Latin.	French.	German.	Mathematics.	Chemistry and Physics.	
Max.	300	100	400	400	200	400	400	400	400	400	400	400	2600
1	270	88	384	330	180	—	280	—	306	—	380	—	2218
350	244	93	302	198	140	197	—	—	168	—	124	—	1466

In view of the advantages already discussed, and the useful training in Civil Service subjects which these examinations afford, a youth who has left school early, and must earn his own living while making his way in the service, could scarcely make a better start than in the modest capacity of a boy clerk.

In the superior divisions boy clerks have captured many valuable appointments.

ERNEST A. CARR

The Famous Theory of Natural Selection in Relation to the Problem of Organic Evolution.

CHARLES DARWIN

DARWIN set us free. Before any discussion of his work and of its modern standing, let us be clear about that. As Professor Kellogg, of Stanford University, California, says in his admirable volume, "Darwinism Today," "Let no ambitious student hesitate to take up the search for the truth about evolution from the notion that biology is a read book. The 'Origin of Species' was the first opening of the book—that the world recognised, at least; poor Lamarck opened the book, but could not make the world read in it—and that time when it shall be closed because read through is too far away even to speculate about. With Osborn let us join the believers in the 'unknown factors in evolution.'"

"The Origin of Species." This distinguished critic's estimate is just. Darwin first effectively opened the book of biology, in which the world has been reading, with ever-increasing interest, ever since the publication in 1859 of the epoch-making volume on "The Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life." The authoritative and final edition of this work is now published by Mr. John Murray at half-a-crown, and it must be in the library of every educated or educable person. It is the book which set the mind of man free in regard to the most important and profound subject, the question of the Psalmist, "What is man, that Thou art mindful of him?"

"Poor Lamarck" made a noble failure; Spencer was looked upon as a "mere philosopher," without first-hand knowledge; Darwin came to the subject with a great equipment, and he succeeded. His book, only a portion of what he had collected for publication during a period of twenty years, so marshalled the facts that, at the very least, men might henceforth think freely about organic evolution, untramelled by the Book of Genesis. Not that "The Origin of Species" is another and final Book of Genesis, as most men of science thought in the nineteenth century, and some few survivors think here and there today. But that book showed organic evolution to be the truth, though its explanation of the process can no longer be accepted as more than a contribution to the lethal, or negative, side of the process.

Darwin's Hatred of Controversy. A few words are essential as to the character of the man. He had by heredity a sure place in the intellectual life of this country. One of his distinguished grandfathers had already taught organic evolution. He had ample means, and was without need of writing sensational books for money, so much the greater being the significance of the fact that he wrote the most sensational book of all time. He was not a public speaker, and detested controversy, being endowed with the peaceable and gentle temper which Josiah Wedgwood appears to have handed on to all his descendants, including Charles Darwin, Francis Galton, and the sons of the former. This quality was really an advantage, in the circumstances. Tremendous fighting was needed, and Huxley in this country—"my good and admirable agent for the propagation of damnable heresies," as Darwin privately called him—and a no less doughty warrior in Germany, Ernst Haeckel, did all that was needed.

Darwin's personal moderation, love of truth, and dislike of annoying people lent immense advantages to his book. Whenever the controversy got back to his own words, his opponents were confounded. He had not said what they attributed to him; he had not claimed more for his work than it proved; he had not decried the work of his predecessors. Indeed, in one most notable respect, typical of the man's love of truth, he weakened his own case for the fact of organic evolution. This instance prepares us for what later follows regarding the work of Mendel.

Nature Does Nothing by Leaps. It is well known to everybody that living species occasionally produce "sports"—forms startlingly unlike their parents and their race, and sometimes entirely unprecedented. A biologist advancing—against the overwhelming majority of his generation—the theory of organic evolution might well direct his attention to the occurrence of such "sports," and try to show that they might become the founders of new species. Their existence strongly suggests, on the face of it, that the general rule of like breeding like, and of species being therefore immutable, has serious exceptions; and any ordinary controversialist would, it may be assumed, have made the most of such exceptions.

Not so Charles Darwin. Examining such evidence as was before him, he considered that "sports" were of no significance, or practically none, in relation to the problem of the origin of species. He repeatedly quoted the ancient verdict that "Nature does nothing by leaps," and could not allow himself to argue that "sports" really furnished exceptions to that rule. Huxley hinted that Darwin might prove to be unnecessarily handicapping himself by his rigid acceptance of the ancient dogma about Nature; and today we believe that Huxley was right. But Darwin's attitude was characteristic of him, and cannot be forgotten. No less

characteristic was his attitude towards Lamarck, whose theories, as we have seen, he accepted. Whenever Darwin is quoted by uninformed or biassed controversialists, against the French pioneer, it should be remembered that Darwin was a Lamarckian, explicitly, expressly, and consistently.

Darwin's Varied Studies. Of Darwin's minor studies a word or two must be said before we consider his chief contribution to biological theory. He studied the beneficent influence of worms upon the soil; the facts of orchids; the lives and activities of the living beings which make what we call coral, and many other details of natural history. He wrote a delightful book upon the expression of the emotions in man and animals, but in this respect only did he concern himself with the problems of mind—and even then only with physical manifestations of mind. We cannot call him a psychologist, and still less a philosopher. He was a naturalist, and has himself told us that his mind became confused when he attempted to consider the more abstruse objects of thought.

As a Lamarckian, he believed that influences acting upon the parent may modify the characteristics of the offspring. That is part of the problem of heredity, or genetics, as Professor Bateson has taught us to call it. But Darwin also contributed an explanation of his own to that part of Lamarck's theory. That explanation, which he called "pangenesis," cannot be accepted —though Mr. Cunningham's recent theory, that hormones liberated by the bodily tissues may affect the germ-plasm in a specific way, is a kind of analogue of "pangenesis."

The Theory of Sexual Selection. Darwin also had a theory of "sexual selection," which he elaborated in his second great book, "The Descent of Man," published in 1871; and though this is not his chief theory, it requires a little more notice than those already mentioned. Darwin had only alluded to man in a single sentence in the "Origin of Species." He inserted that sentence because honour compelled him to; he inserted no more because he felt that the book carried cargo enough, and had enough dangers to face without involving it in all the prejudices that would be aroused by the clear assertion that man is descended from humbler forms of life. But there were plenty of friends and enemies to make it plain enough that the theory of organic evolution must include man himself, and it therefore became Darwin's duty to write a book upon the subject.

The theory of "sexual selection," as there stated by Darwin, deals more, however, with the lower animals than with man. It argues that certain types of males and females respectively are more likely to find mates, and so to produce their like, than their rivals, less highly endowed with certain qualities. For instance, if stags fight each other for the possession of females, certain kinds of horns, and so forth, might survive, and be perpetuated. Indeed, "sexual selection" is none other than a variant of "natural selection." Another form which it may be supposed to exhibit depends upon actual æsthetic preferences on the part of the females. Thus Darwin supposed that the vocal powers, and the beautiful plumage, of many kinds of male birds are due to the preference exhibited for such qualities by females during many past generations.

Objections to the Theory. The objections to the theory of sexual selection, as a real explanation of the facts which it was designed to cover, are nowadays seen to be overwhelming Like natural selection itself, this theory offers no explanation of origins at all, but merely argues that certain individuals, not having the feature for which it is sought to account, would be left unmated and without posterity. This is no explanation of the nightingale's song, nor the plumes of the bird of paradise. Further objections of many kinds are almost as formidable. But the student is not therefore safe in regarding this famous theory as unworthy of his careful study. In forming it, as in forming its more famous predecessor, Darwin was arguing to animals from man. He saw that, for instance, men choose beauty in women, so that whatever is regarded as ugliness will have a smaller representation in posterity; and it was from such a fact that he argued for an analogous choice on the part of, for instance, female birds among the decorations of their suitors.

The Application of the Theory to Mankind. Now, though we cannot accept the application, the original fact from which Darwin argued remains. In other words, even though the theory and practice of sexual selection among the lower animals be of small importance, or none, they do assuredly obtain *among ourselves*, and must be producing still, as they must have produced throughout many ages, results which may be of incalculable importance. The modern aspiration which is called eugenics, or the attempt to ennoble the human race, primarily by making parenthood the privilege of the worthiest, must never cease to reckon with the great fact of sexual selection among ourselves. Eugenics needs to ask what types of individuals of each sex are chosen, and what types are rejected, as partners by members of the other sex. Nor does it follow that, if qualities of no profound importance in themselves seem to have selection-value, the results will be equally unimportant.

It was Darwin himself who taught us to note how certain characteristics of living beings are apt to be correlated with others, apparently quite diverse and irrelevant. If, for example, red hair and a hot temper are thus correlated, and red hair be a characteristic highly rated in sexual selection, the result will be not merely that mankind will become more commonly red-haired, but also that it will become more commonly hot-tempered. The illustration may seem trivial, but not to any reader of Darwin, who knew that cases apparently even more trivial might really be of importance for the student of racial evolution.

No serious student of eugenics, therefore, can neglect a most careful study of Darwin's theory of sexual selection, quite apart from its supposed

application to animals, but for its certain application to the future evolution of our own species. That two young people should love each other may be an everyday affair, but Darwin approvingly quotes the observation of Schopenhauer that, though we may smile, in fact it is the future of mankind that depends upon the love-choice of the sexes; and hence the eugenist and the biologist and the psychologist are all profoundly concerned to learn what are the characters in each sex that are chosen by the other, and what are the other characters, perhaps vastly more important, with which those chosen characters are correlated.

The Tendency of Like to Mate with Like. Professor Karl Pearson has made an interesting contribution to this subject in his theory of *homogamy*, or the tendency, which he considers that he has proved by statistical inquiry, for like to mate with like. If, as is probable, sexual selection—in mankind, at any rate, tends to be homogamic, so that brown eyes tend to marry brown eyes, blue eyes blue, tallness tallness, and tendency to longevity its like, we shall realise that here is a factor which must tend to bring into existence well-marked differences or types within our species. On the other hand, if we all tended to marry opposites, individual differences would always tend to be neutralised, and each generation would tend to show less individual variety as a result.

It may here be added that, though Professor Karl Pearson himself denies the application of Mendelism to mankind, that theory of heredity tends, as we shall later see, very much to accentuate the importance of his own theory of homogamy, or the natural tendency towards the mating of like with like. These brief sentences will suffice to show the student how much may still flow from the fertile idea which we owe to Darwin under the name of "sexual selection."

That is only a special case of the chief idea which Darwin elaborated under the name of "natural selection." He saw that certain forms of life are perpetuated by man, through his *artificial selection* of certain individuals for parenthood—large roses, fast horses, clever dogs, and so forth. Thus are produced races of living beings which conform in varying degree to certain requirements of man, the selector. Darwin thence argued that an analogous process of selection might occur in Nature, and might account for the fact that living species often *seem made* to meet certain requirements of Nature. Living things are adapted to their environment. If they were not specially created with these adaptations, the evolutionist must seek for some other explanation of this great central fact of the living world; and natural selection was the explanation given by Darwin and several others before him in the first half of the nineteeth century.

Racial Effects of the Struggle for Existence. As in the case of his celebrated contemporary Alfred Russel Wallace, Darwin was led to the theory by reading the famous book of the Rev. Thomas Malthus on "The Principles of Population." Malthus was concerned entirely with man. He pointed to the fact that population tends to press upon food-supply, which cannot keep pace with it, so that there is an immense mortality, not least among the young and immature. Malthus, therefore, counselled delay in the age at marriage. Darwin and Wallace, independently reading him, asked themselves the question: What would happen in these circumstances described by Malthus, not merely among human beings, but throughout the living world?

The answer is that the mortality would necessarily be selective, and the survivors would be those *best fitted* to survive in the circumstances. Imagine such a process continued from generation to generation, and the result would be the production of races the individuals of which would be more adapted than their remote ancestors to the circumstances around them. In other words, the theory of natural selection offers a mechanical explanation for the facts of adaptation, which look as if they were the result of creative design.

Two Conditions Essential for Natural Selection. The doctrine known as neo-Darwinism, which has two or three representatives still surviving in this country, though practically nowhere else, insists that the theory of natural selection is all-sufficient as an explanation of organic evolution. But if we turn to Darwin's own account of his theory, we find our attention directed to a point which the neo-Darwinians forgot.

The process of natural selection requires certain conditions, and cannot occur without them. The first is that there must be *over-production* of life, with a consequent struggle for existence. If and where there is room—which, in effect, means food—for all, there will be general survival and no selection. This condition of over-production does generally obtain throughout the living world, the fecundity of which is one of its most amazing and universal characteristics. Hence there almost always, if not always, *is* a struggle for existence, with a large mortality. So far the theory is unassailable.

"Survival-Value" Characteristics. Another condition required, in order that the struggle for existence shall result in changing the characteristics of a race, is that the particular characteristics of the survivors—the characteristics which, in Professor Lloyd Morgan's excellent phrase, have "survival-value"—shall be inherited by their offspring. That is obviously essential. If large bones, or oily feathers, or swift limbs, or tough wood, or big brains have survival-value in individuals possessing them, who accordingly are first, or alone, served at the table of life, those features must be reproduced in their offspring, or no racial evolution in the directions in question will result. Therefore the theory of natural selection requires, no less than *over-production*, the second great condition called *heredity*.

Beyond all question, that condition is complied with. The experience of artificial selection

proves it every day. Fast horses are bred from, and their offspring are faster than those of slow horses; and so on. But obviously the exact laws of inheritance must be studied, for *all theories of organic evolution are necessarily at the mercy of the facts of heredity.* To assert the resemblance of parents and offspring will not suffice; we must know it exactly.

Variant Types Essential. For observe, the theory of natural selection, which requires the fact of hereditary *resemblance*, also requires the fact of *difference*, technically known as *variation*, between parents and offspring. That is the delicate and profound paradox. There must be resemblance, or the selection of the best-adapted will not give us the best-adapted in the next generation. But there must be better and worse adapted in each generation before natural selection has any material to select from. If the artificial breeder has no variations to choose among, he cannot take the initial step towards the "creation" of a new type. He may have an ideal and intelligent purpose, but he is impotent.

Now, just as certainly as the two previous conditions of evolution through natural selection are complied with, so also is this. Variation is as basal a fact of the living world as heredity. Like begets like, but not quite like; and sometimes, as we have seen, the unlikeness may be so extreme that we are astonished by it, and call the novel individual a "sport." The nectarine upon a peach-tree is such a sport, and so is a Burns or a Shakespeare or a mighty genius of any kind in our own species. If such extreme variations could be mated with one another, and if they "bred true," we should at once have new races. Such processes might *conceivably* occur by natural selection if the novel characteristics had "survival-value."

The elegance, the wide applicability, and the limitless possibilities of this famous theory will now be apparent to the student. It consorts with the most general and constantly exhibited facts of the living world, and we feel that nothing now remains but to work out the details. But the cautious reader, noting each assumption and proviso in the statement of the theory, will realise that when all possible things have been said for it, when the limitless claims of the neo-Darwinians have apparently been warranted, one tremendous fact has been ignored. Natural selection—acting among the forerunners of birds, produced in over-abundance, some with few feathers and some with many, and each tending to reproduce their like—will undoubtedly tend towards the evolution of such feathered races as we know; *but there must be feathers first.* Similarly with the sub-species of natural selection called sexual selection. The female bird may choose the best exponent of *bel canto*, and his voice may be inherited by their offspring, but imperatively the voice must be there first.

Where Darwin Failed. In a word, natural selection provides a complete explanation of everything but what alone matters—*the origin of variations.* The artificial selector knows by wearisome experience that if the species upon which he is operating *will not produce* what he wants, his task is hopeless. The crux of the problem of organic evolution remains, not so much as referred to by the boasted theory which made what seems to us nowadays such an incomprehensible stir in the nineteenth century.

Not that Darwin was ever really deceived. All his life he was accumulating facts that bore upon the fundamental problem of variation, and he published a large number of these in his work on "Animals and Plants under Domestication." He would have delighted to read, to verify, to amplify, and to seek to interpret the work of his contemporary Mendel, whose name he never heard. That is a tragedy of science to which we must immediately come, but we shall err if we suppose that Mendel's law will help us to understand adaptation. Upon that central problem of organic evolution it does not so much as bear at all.

Our Debt to Darwin. Our debt to Darwin must be clearly defined before we leave him. At the end of his life (1809-1882), his mortal remains were buried in Westminster Abbey, with general approval. Throughout the civilised world his name is never mentioned by thinking persons but with reverence. He has been hailed by many writers as the greatest biologist of all time. Was all this as great an error of judgment as that which supposed the destruction of the incapable to account for the origin of the capable? No, indeed. Darwin entirely failed to solve the problem of organic evolution, and many now realise that all attempts to solve that problem on mechanical principles must fail. But never since the day on which the "Origin" was published can honest and thoughtful men have doubted, reading it, that organic evolution has occurred. Overwhelming evidence, sufficing to rank as demonstration, of that stupendous fact is what Darwin gave us. More than half a century later the explanation of the process is still unfound by any search among physical or mechanical principles, but Darwin's glory remains, as does that of Newton, who demonstrated, centuries ago, that law of gravitation which no one has yet explained.

The triumph was one of character. No writer more than Darwin illustrates the truth of the saying of Buffon, the great evolutionist of an earlier age, that "the style is the man himself." Darwin's books are "the very life-blood of a master-spirit." Honesty, patience, reverence for his subject, love of truth, anxiety to be fair, inexhaustible eagerness for new evidence, absolute freedom from any desire to hurt people or to strike directly at conventional religion or prejudice—these are some of the qualities of Darwin's character which, on its private side, made him the best of friends, an ideal husband, a perfect father. Never in all time did new truth, apparently so subversive of human dignity, of justice, of kindness, find a champion so dignified, so just, so kind, as Charles Darwin. C. W. SALEEBY

Different Ways of Conducting Export Business. Importance of Right Packing. Indents, Invoices, and Insurances. The Use of Consular Invoices and Codes.

THE EXPORT TRADE

When we remember that the exports of the United Kingdom now amount to over six hundred million pounds a year, we may well ask how this vast volume of business is carried on. What is the export trade, and how is it handled? It was in the export business that many of our great merchant princes of other days as well as of these times obtained their riches, and the very fabric of the British Empire is built up upon its overseas business. The Empire exists for business purposes. There would be no value at all in a mighty empire if it meant nothing more than the possession of so many square miles of the earth's surface, and the necessity of maintaining an army and navy to prevent other nations from coming and taking some of these square miles for themselves.

The Value of Empire. But the possession of thickly populated colonies and dependencies in all parts of the world means that we have under our own flag and government, and therefore under our immediate control, vast markets for the produce and manufactures of these islands. Of course, we send our goods to all the countries in the world, but of the huge sum which our exports now amount to, more than 36 per cent. represents trade done with countries that are British possessions.

The Need for Overseas Markets. Modern machinery has so multiplied the output of our manufactures that we produce far more than our own people can consume, and so markets have to be found in other lands for the goods we ourselves are unable to consume. The export business of the country is so much a matter of shipping, and shipping is so much a matter of imports, that it is difficult, in describing how the export and import business of the country is handled and how the goods are shipped, to know where the line can be drawn between the one and the other, so that a clear idea may be conveyed of the principles involved in these very important branches of business.

Different Methods of Export. For the sake of convenience it will be best, perhaps, to give some account first of the way in which our export trade is conducted; and at the outset it must be explained that there are three different ways in which this is done. In the first place, the manufacturer of the goods, or the wholesale merchant who is selling them, does his own export business. That is, he receives orders from the buyers abroad, and sends the goods out direct to his customers without the aid of any intermediary firm. His dealings are direct with his foreign or colonial customer. The tendency in the present day is for the export trade to develop on these lines.

The Value of Consuls. Owing to the appointment of consuls in all important commercial centres, and the opening up of the world by means of telegraph and telephone and cheap and rapid postage, it is quite easy for the manufacturers to get into close touch with likely purchasers. They are able, also, to learn quite easily how goods should be packed and shipped for the most distant lands, and, knowing all this, they find it much more satisfactory to do their own business without the intervention of a third party, for not only are they thus in personal touch with their actual customers, the men who are handling and selling their goods in the far country, but they save a great deal of the middleman's profit or commission.

Commission Agents. The second method by which the export trade of the country is carried on is by means of what are known as commission agents. These are individuals or firms who receive orders for all kinds of goods from foreign buyers, obtain these from the different manufacturers in this country, pack them and ship them, sending their own invoices to the buyers.

Formerly, practically all the export trade of the country was carried on by commission agents, and very lucrative the business was, for the agent obtained a commission from his customer for all the trouble he took, and also received a commission from the manufacturer in the form of a discount off the goods bought from him. The commission agents had everything in their hands in former days. For then no one but themselves knew anything about the needs of foreign countries, or the methods of disposing of the goods when they got there. It was very difficult then to find out anything, but nowadays any manufacturer can learn from the Board of Trade and our consuls abroad all he wants to know about any part of the world—the character of the people, the kind of goods they are likely to buy; and the foreign buyer also can, through his consuls here and his own government officials, learn all he wants to know about the manufacturers of the goods in this country. By dealing direct the foreign buyer, of course, saves the agent's commission.

As a result of all this the manufacturers and the buyers are more and more getting into direct contact, and are no longer content to allow their business to be done at second-hand through a commission agent. At the same time, a great deal of business is still done by commission agents, and they hold a high and honourable position in the export trade of the country.

Forwarding Agents. The third method by which export business is carried on is that in which the foreign or colonial buyer orders the

goods he requires direct from the manufacturers in this country, but instead of allowing them to ship out the goods direct in so many small packages, he asks them to send their goods to a forwarding agent. When the various items have all come to hand from the manufacturers, the forwarding agent has them packed suitably and sent off as one consignment.

It might be asked why a foreign buyer should find it more economical to order direct and have the goods sent through a forwarding agent. The reason is that the individual or firm which is a forwarding agent pure and simple is able to charge less commission than an ordinary commission agent; for whereas the former has no great amount of capital utilised in the execution of any particular order, the commission agent has a great deal of capital employed in the actual buying of the goods which his customer has ordered, and interest has to be charged on this so that the agent's business may prove remunerative.

Further particulars about some of these three methods of carrying on the export business are given below, but it is important that every business man should have a clear idea of how the methods operate in practice and just how they differ from one another.

Interesting the Foreign Buyer. In some one of the many ways in which the foreign and colonial buyer is made to take an interest in our home products, the manufacturer and he are brought into contact. This may be achieved by sending price-lists to a given list of traders in a directory of foreign merchants, or it may be by recommendation, or it may be that the foreign buyer has discovered the name of the English manufacturer and has first approached him, asking for samples or patterns and prices. But in whatever way the introduction has been brought about, the manufacturer and buyer are in direct touch with one another, and the order is at last given.

The Meaning of an Indent. Orders from foreign buyers are called indents. The word comes from the same root as our word "teeth." The orders were formerly written on sheets torn in a zig-zag, indented, or tooth-like line, from a counterfoil, but now they are written in any way that is convenient. An indent should bear full instructions, not only as to the goods required, but also as to the method of packing required, the route and shipping company that is to be used for the conveyance of the goods to their destination, the terms, the insurance, and the method of payment.

The Importance of Proper Packing. The question of packing is a very important one, for many things have to be taken into consideration. First of all, there are the laws and regulations of the country to which the goods are going; also the customs and prejudices of the people there. Take, for instance, the export of cotton goods, linens, and cloth materials generally, which constitute so large a proportion of our total exports. These are folded in certain recognised ways, according to the particular material in question, and if they are going to India they must, according to the laws of that dependency, have the length distinctly stamped upon the cloth.

Packing in Bales. The usual method of packing such goods for export is in bales, though sometimes cases are used, but they are much dearer. First of all, it takes an expert packer to see at a glance the best way of putting a number of articles of different sizes and shapes together, so as to get them into the least possible space, and to avoid damage in transit. The bales are pressed in steam or hydraulic presses, and hoops of steel are passed round and fastened with rivets to hold them in position.

For the Chinese market, however, stout manila ropes are used instead of steel hoops, this method of fastening the bales being, for some reason, preferred by the Chinese. In pressing the bales great power is used, for it is important to get each package into the least possible compass, the freight of this class of goods being charged by measurement, and not by actual weight.

Some of the presses exert a force of as much as two tons to the square inch, and unless the packing of the bales is done by those who understand the business, there is likely to be a springing of the bale later on, which may result in damage to the goods or to the bursting of the hoops. To prevent this, the bale must be kept in the press sufficiently long to make the compression permanent. Expert knowledge is also required in packing the bale so that the hoops shall not damage the contents.

How the Export Trade is Affected by Native Prejudice. For the outer covering of bales tarpaulin is generally used, as being very durable, soundly waterproof, and comparatively cheap; and inside this is a double covering of canvas. Tarpaulin, however, cannot be used for goods going to Morocco, as certain animal fats enter into the composition of tarpaulin, and the Moors, being fanatical Mohammedans, find the use of animal fat in this way conflicts with their religious ideas. A kind of linen oilcloth, in the preparation of which only vegetable matter is used, is therefore generally adopted as a covering when goods are being sent to Moroccan ports.

Such a matter as the outer covering of a bale may seem a trivial detail, but, as can be seen from what has been said, it means all the difference between success and failure, between profit and loss. It is only by studying the prejudices, religious or otherwise, and the likes and dislikes of prospective customers, that the intelligent business man is likely to build up a big export trade. It is here that the English merchants and manufacturers have been very largely at fault in the past. Knowing that their goods were the best in the world, they thought that this was sufficient, and that they could pack the goods just as they liked. Other manufacturing nations, such as the Germans and the Americans, have come along, and have met the prejudices of foreigners, and have taken a good deal of trade that should have come to us. Now, however, we have

realised the truth, and all really live British merchants and manufacturers are very careful to take these small yet important points into full consideration.

Packing for Climatic Conditions. Then, again, in the packing of foodstuffs great care has to be taken that the style of package will enable the contents to remain fit in the climate to which they are going. If they are going to hot countries, for instance, such as India and Africa, the contents must be tested exhaustively at the temperature they will have to stand, and most of the foods now being sent away to such countries have to be sterilised and fitted with vacuum coverings. Modern scientific methods of preparing and packing foods have greatly simplified this branch of business, and have enabled a great volume of trade to be done which would formerly have been quite impossible.

The Sizes of Packages. Many other points must come into consideration in packing for export. For instance, goods going to mountainous countries not well supplied with railways, such as some parts of South America, should be packed in bales or cases of moderate size, as they have to be conveyed over mountain paths by mule or cattle waggon, and there is great difficulty in moving them if they are large and unwieldy. As showing how useful it is to follow the reports of the British consuls in different parts of the world, we may give an extract on this point from the report of the British consul at Bogota, in Colombia.

Difficulties of Transport. "Goods to arrive at any interior Colombian town," he says, "must be packed for mule transport whenever this is possible, but the requirements for this particular form of transport vary according to the quality of the road over which the merchandise has to travel; on some roads, that is to say, a mule can carry a load that he could not on another; sometimes it is a question of weight, sometimes of length of the road, and whether the road is muddy, marshy, rocky, precipitious, or tortuous, with rocky defiles, etc.; and sometimes the load can only be transported by bullocks where mules cannot travel.

Uniformity of Package Desirable. "Another question to be considered in packing," he continues, "is the equality of loads. A large consignment of merchandise packed in an infinite variety of shapes, weight, and size may be kept waiting until each package can be paired; if this cannot be done with one of the same consignment, the carriers will pair it with one of another consignment, for which they will patiently wait months if necessary, to the loss and annoyance of the consignee, who, perhaps, will ultimately have to pay exorbitant special rates to obtain his goods which careful packing might have avoided. Again, the question of goods arriving in the dry or rainy season, some roads becoming almost impassable in the latter period, makes a difference as to the method of packing, and consequent economy in transport. Shipments that are too heavy for mule transport are conveyed by bullock carts in the few parts where a suitable road exists, or are carried on men's shoulders at enormous expense."

Value of the Board of Trade Publications. It is not possible, of course, in the compass of an article to describe the various methods of packing goods for different countries. This must be learned by actual experience in the shipping department of a merchant or manufacturer. A great deal of information, however, can be acquired by studying the Board of Trade Journal and other similar publications, and also the consular reports, similar to the one quoted above, which are issued from time to time at the price of a few pence.

If there is any particular difficulty in connection with exporting goods to a certain district, the Board of Trade may be able to render assistance; and if the necessary information is not to be obtained in London, it is often worth while to write out to the British consul on the spot, whose name and address can be furnished by the Board of Trade office. The officials of this Government department are always extremely courteous, and are ever willing to lend assistance where they can.

The Most Expensive Packing. The most expensive form of packing, that of wooden cases lined with zinc, is necessary for some countries where insects, such as the white ant or termite, will eat through anything but metal. It is the only way of preserving the goods when they get to their destination. Large firms of manufacturers make their own cases, but merchants and the smaller manufacturers get firms of case-makers, who specially devote themselves to this business, to make their cases for them as they are required.

Marking the Packages. The method of shipping goods is dealt with in another part of the BUSINESS section of this book, and the particulars given there need not be repeated here. It should be mentioned, however, that when the goods are packed ready for despatch to the port of embarkation the cases must be clearly and carefully marked. Stencils and a hard brush are used for this purpose, and the marking is done in bold, plain lettering with black ink.

It is usual to put on each individual package a distinctive mark, such as a triangle, a diamond, a star, a circle, or some other geometrical figure, with the initials of the firm to whom the goods are consigned and the number of the indent. This mark is for the purpose of rendering the whole of the packages of a consignment easily recognisable at a glance. Underneath the mark is stencilled the name of the port to which the goods are going. The mark should be about sixteen or eighteen inches in width and height, and the letters should be at least three inches high. It is wise also to mark on each package its measurements, and in certain instances it is necessary to put on the gross weight, with the tare and net weights, not only in avoirdupois, but in kilogrammes also. Of course, each package will bear in very clear letters and in a

conspicuous position, so as to be easily seen and read, the name and full address of the firm to whom the goods are going.

The Metric System in Business. Reference has been made to the need that often arises of marking on the bale or case its gross and net weights, not only in avoirdupois, but according to the metric system, too. This shows how necessary it is for anyone whose business is connected with the export trade, and who wants to be efficient at his business, to know thoroughly the metric system of weights and measures, and the money systems of other countries, especially those with which he or his firm are doing business.

The metric system, which was adopted by the French Government in 1795, has now been adopted by practically all countries except the United Kingdom; but it is interesting to know that James Watt, the English inventor of the steam-engine, devised a decimal system in 1783, and is said to have submitted his proposals to the French Government, who were so struck with the advantages of the system that they eventually adopted it. Many attempts have been organised to make this the regular system in this country, but so far without avail. It is, however, quite easy to learn, and any man whose work lies in the export trade should be able rapidly to change English weights and measures into their metrical equivalents, and English money similarly into the decimal equivalents of other countries. It is curious that all the civilised countries of the world, with the exception of the United Kingdom and a few of its colonies, now have a decimal monetary system. It is clear, therefore, that an export man must have a thorough grip of the decimal system.

Insuring the Export Goods. The goods having been despatched to the wharf or dock from which they are going, the next thing is to insure them, and there are two methods of doing this, known respectively as F.P.A., which means Free of Particular Average, and W.P.A., which means With Particular Average, or, as it is often called, A.A.R. or A.R., Against all Risks.

With F.P.A. insurance any small damage will not be paid for by the insurance company; only a total loss—as, for instance, if the vessel sinks at sea, is burnt to the water's edge, and so on. This is the method usually followed where the goods are packed in zinc-lined cases, or where they are of such a character as not to be easily spoilt by sea-water or rough usage. Goods likely to be easily injured should be insured W.P.A., and for this, naturally, a higher premium is charged than for the other. The W.P.A. rate, however, is reduced by the insurance companies for goods that are packed in zinc-lined cases, as the risk of injury to them is so much less than where they are less carefully packed.

The Meaning of Particular Average. It is, of course, essential that the exporter should know exactly what his insurance covers; and as there is often a great deal of misunderstanding about this, it may be well to explain here that Particular Average, while it insures the merchant "against any injury that his goods may sustain from depreciation in value by their being sea-damaged," does not mean that if the goods arrive at their destination in a damaged condition they may be thrown upon the hands of the insurance company or underwriter, and a claim be made for the full value. The receivers of the goods must dispose of them themselves, and claim merely for the cost of the actual damage. It has been laid down that "the true mode of calculating a partial loss on goods sea-damaged, and ascertaining the extent of the underwriter's liability, is by a comparison between the gross produce of the sound and damaged goods, the ratio of depreciation or loss thus found by a comparison between these two being then applied to the sum assured."

What to Insure. Some merchants insure only the invoice value of the goods, with perhaps a slight percentage over to cover profit. But it is much better to insure the goods for such an amount as shall cover not only their cost as invoiced, with estimated profit, but also the various shipping charges, the Customs duties, and the insurance dues; for in order to recover the full amount of the loss, it is necessary to insure for a sum equal to the gross value of the goods.

It is wise, when insuring goods to be sent by ship, to consult not only one or two insurance companies, but also Lloyd's. The various rates should then be compared, and the best selected for its lowness and its discount. The next thing is to take out a provisional note, which is merely a form signed by the manager of the insurance company, stating that an insurance for such and such an amount has been taken out. If this provisional note is duly signed by the manager, and not by a clerk, then the shipper is covered for the amount set forth. But it *must* be signed by the manager himself to be valid.

Special Risks. For special risks, owing to the nature or conditions of the country to which the goods are going, there are special rates. For instance, when goods are sent to the Pacific coast of South America, it is the custom to let the insurance include the earthquake clause. The premium is higher, but the goods are then covered against damage or loss by this visitation, so frequent in that part of the world. A higher rate than usual is also charged by the insurance companies or underwriters on goods that have to make a long journey across the mountains by ox-waggon or pack-mule; and the merchant should see that these special risks are definitely mentioned in his note and in the policy, which will be made out and follow in due course.

Invoicing the Goods. The various shipping documents are dealt with in the article on "Shipping," in this BUSINESS section, but the method of invoicing the goods may be

mentioned here. The greatest care must always be exercised in making out shipping invoices, as endless delay and trouble, and even great financial loss, will be incurred by mistakes that are perhaps mere lapses of the pen. There is certainly no room in the export business for carelessness.

As described in the chapter on "Buying," goods exported from one country to another are sold on various conditions—F.O.B., C. and F., C.I.F., Franco, F.A.S., and so on. The invoice will contain the date, the quantities, and detailed descriptions of the goods, the price, with the amount of the charges and the description of what the charges include—F.O.B. London, or whatever it may be—with the measurements of the bales or cases, the numbers and special marks on each, and the route or mode of transport.

Making out a Complete Invoice. Where the invoice is to be complete, including all the charges up to the time that the customer takes over the goods, it is particularly necessary that there shall be no mistake in the measurements, otherwise the freight charges cannot be worked out correctly. There are various items that have to be charged upon the invoice, such as the stamps on bills of exchange, bankers' commission, and so on. These things, unless carefully watched and charged, may easily amount to quite a respectable percentage.

Invoices when going to a foreign land should be made out in the language of the country to which they are sent, and they afford an illustration of the importance of anyone engaged in the export trade knowing languages. Not only is this necessary for the invoices but for the purpose of corresponding with foreign firms. It is essential if the best and biggest business is to be done that the outward correspondence should be conducted in the language of the buyers. With the facilities that there are in these days for learning languages, either from books like the new HARMSWORTH SELF-EDUCATOR, or by attendance at classes, there is no excuse for a young man who desires to get on in the shipping and export business being ignorant of the principal commercial languages of the world.

Consular Invoices. In addition to the ordinary invoice, it is necessary, when shipping goods to the United States, to South America, and to various other countries where import duties are levied, to have what is known as a consular invoice drawn up. This is to facilitate the clearing of the goods on arrival, so that the receiver can get them with the least possible delay. Certain ports in these countries where the import duties are imposed are constituted ports of entry, and at each there is a staff of Customs officials, whose duty it is to examine all merchandise coming into the country through that port.

The manner in which the consular invoice is made out and the way in which it facilitates delivery at the other end are as follows: The form for the consular invoice is obtained from the consul of the country in question, and on this has to be written full particulars of the goods, the number of cases, the exact contents of each, and their values. To these particulars are added the cost of the cases, the freight, insurance, and cost of the consular invoice. This latter varies for the different countries. The name of the sender is then signed at the bottom of the invoice. On the other side is a declaration form, the blanks of which have to be filled in. All being duly in order, the invoice must be taken to the office of the consul and its accuracy sworn to before a commissioner for oaths. The consular seal is then affixed to the document The invoice is made out in triplicate and each of the copies has to be sworn. Two of the copies are kept by the consul, who sends them to the port of entry to which the goods are going. The other copy is given to the sender of the goods, who attaches it to the commercial invoice and forwards to the receiver of the goods.

The Use of the Consular Invoice. The consular invoice is accepted by the Customs authorities as an accurate description of the goods, and the duty is assessed upon it instead of upon the actual goods, the cases of which are not opened unless it be perhaps an odd one or two for formal testing. Without the consular invoice there would be endless difficulty and delay. The invoices vary in cost. For the United States they are 10s. 4d. ; for the Argentine Republic, 5s., and so on. It is, of course, essential that the rules and regulations of each individual country should be observed minutely in making out the consular invoices, as anything that can be construed into a wrong declaration would result in a fine.

There should obviously be someone in every shipping office and export department of a manufacturer's business who can read in the original language the Customs regulations of the country to which the goods are sent. Further, it is necessary to get the co-operation of the customer abroad in specifying the head under which the goods are to be described in the declaration.

It must be remarked that the consuls of the various countries are usually extremely courteous, and the officials in their offices are generally very willing to give every information and facility to help shippers and merchants. Some countries do not require the consular invoices to be signed by their consul in this country and forwarded directly by him. The filling up of the consular invoice is a work requiring not only great care but great knowledge, for some countries are so particular about details that in the case of machinery they even insist upon the weight of each separate kind of metal being entered up.

Goods Sent on Consignment. When goods are sent abroad not on a definite order from a buyer, but to a firm with a request that they may be sold to the best advantage, they are said to be sent on "consignment," and the goods are called "a consignment." In such a case a *pro forma* invoice is sent—that is, an

invoice "for the sake of form," which will give the consignee an idea as to the value of the goods and the price at which they must be sold in order that a profit may be made. The consignment is not debited to the consignee as a sale, but the goods are entered against him at the cost plus the various expenses incurred in sending them out, such as freight, insurance, and so on. When the goods are sold the consignee deducts the amount of the commission agreed upon and forwards the balance to the consignor. By placing this amount received against the actual cost of the goods entered up, it will be seen at once just how much actual profit has been made.

Watching the Foreign Markets. In sending out goods on consignment, the foreign market reports should be watched very carefully, so that the goods may be sent out at such times as are likely to prove most profitable to both consignor and consignee. As the sending abroad of a large consignment would mean the withdrawal of a considerable amount of capital from the business while the shipper was waiting for his goods to be sold and the money sent to him by the consignee, it is usual for the shipper to draw upon the consignee for a part of the shipment. The draft is then attached to the shipping documents and handed over to the bank, which forwards these to its agent in the place where the consignee lives, and he can only get the shipping documents on paying the draft, unless, of course, he is a substantial man, well known to the bank.

In such a case as has been described the goods are said to be shipped D/P—that is, "documents against payment," or C/D, "cash against documents." If the shipping documents are to be given up upon the consignee's acceptance of the consignor's draft, the goods are then said to be shipped D/A, "documents against acceptance."

The Use of Cable Codes. Any firm that carries on an extensive shipping business has to do a good deal of cabling, and this becomes a very expensive item, for the charge varies from a penny up to about seven shillings a word. To economise as far as possible, an elaborate system of codes has been worked out, and all firms engaged in the export business use some code, either one that is in common use, like the A B C, or a private code, specially adapted to their own requirements. There are also printed codes adapted to special businesses, such as engineering, the cotton trade, and so on.

Code versus Cipher. Codes are used generally in preference to cipher, the difference being that, in a code, actual and pronounceable words are used to represent sentences and phrases, while in cipher figures and sometimes letters represent a secret meaning. The Post Office and cable companies lay down certain rules and regulations for the use of code and cipher messages. The words used in a code, for instance, must consist of not more than ten letters; and only English, German, French, Italian, Spanish, Portuguese, Dutch, and Latin words may be used. If words of more than ten letters are used, then they will be counted as two words each. There are about 320,000 words that can, according to the postal regulations and general convenience, be used in codes. Many words that the Post Office and cable companies would allow have to be rejected because of their similarity to other words, with the consequent likelihood of confusion. Cablegrams written in ordinary plain language may contain words of fifteen letters. In cipher five figures count as one word.

Importance of Studying the Cable Routes. The man engaged in the export business will make himself familiar with the different cable companies, the territory they each serve, and the rates per word for cabling to the places with which his firm does business. In many cases there are alternative routes to the same place abroad, and it will be the business of the shipper to know which is the best line to cable by. Sometimes one is much slower or less reliable than another. He will also study carefully the rules and regulations laid down, which can be learnt from the Post Office Guide. The difference in time between England and the other countries concerned must also be understood, so that at any given time he may know what hour it is at the place where his customer is situated.

Clear Writing Needed for Cables. Of course, it is important that all cablegrams, especially those in code or cipher, should be written with the greatest care. The handwriting should be as legible as print, so as to avoid, as far as possible, any chance of misreading by the transmitting clerk in the post-office. It is obvious that the misreading of a letter in a code cablegram would make the word into another similar word, and perhaps completely alter the sense of the cablegram. Some firms have a code word to go at the end of every message, so that the receiver will know that the message is concluded. It serves also to prevent any fraudulent addition to the message in transit, a thing that has not been altogether unknown abroad. There are some countries where codes and cipher messages are not allowed to be received, such as Turkey, Servia, Bulgaria, Montenegro, and Rumania.

Welcoming Foreign Travellers. In conclusion there is one other point that should be mentioned, and it is an important one. Every shipping merchant and manufacturer will take care to cultivate personally his foreign customers when they visit the United Kingdom. He will take them over his factory or warehouse, and will arrange that they have an opportunity of seeing some of the sights of London and other large cities under proper guidance. Such solicitation for his welfare will make the foreigner sympathetic to the merchant or manufacturer from whom he has goods, and will go far towards cementing the business friendship and connection that has already been established.

CHARLES RAY

Though Mechanical Inventions Bring the Invisible into Sight, Researches Depending on Vision are Limited by the Nature of Light.

HAS SIGHT REACHED ITS LIMIT?

The eye is fully dealt with in a previous chapter in the course on PHYSIOLOGY, where the existence in the retina of what are called the *blind spot* and the *yellow spot* is noted. Considered solely from the standpoint of optics, the retina is a curtain or screen—a mere surface upon which certain rays of light are focussed. Vision does not take place in the retina. The retina is merely the "end organ" or recipient organ of the visual apparatus. The real eye is in the back of the head. If the optic nerve be severed, vision must cease, and this even were it possible to maintain the health of the retina after such an accident. Hence it follows that there are in the retina physical or physico-chemical processes which should be studied by us here, because they are immediately determined by light.

Sight Cells. Entirely ignoring all the less important parts of the retina, let us confine our attention exclusively to those parts which are immediately acted upon by the radiant energy. These are found in the deepest layer of the retina—except for a narrow bounding layer which consists of cells containing pigment that probably has the function of absorbing useless light. The "visual cells," or "rods and cones," [see page 2016], form a kind of palisade which the light reaches after traversing the other retinal layers. The rods are much more numerous than the cones, except at the yellow spot. Their complicated structure does not here concern us, except to know that they contain a complex chemical compound of a dark colour which is known as the visual purple. The cones are very different in shape and do not contain this visual purple. On the other hand, it is more than probable that both rods and cones contain certain highly complex chemical bodies capable of extremely rapid decomposition under the influence of light.

Many distinguished physicists, such as Clerk-Maxwell, have experimented upon the functions and behaviour of these visual cells. It was at one time thought that the cones alone are really visual cells, but it is now known that the rods are also true terminals, though probably of lower development and older in the history of the race—for if they were not, the images of small stars, for instance, would appear and reappear when the eye was slowly moved. The star would not be seen where the rays from it fell upon the rod-occupied interval between separated cones. Certain other facts may briefly be noted. In order to obtain two images at one and the same time, it appears that two cones are necessary. Two objects—for instance, twin stars—so small as to affect only one cone appear as only one object. It has been calculated that there are about three million cones in the retina.

Physical Changes in the Retina. What, then, are the consequences of the impact of light upon the retina? The first point we may note is that the deepest layer of the retina, consisting of the pigment cells to which we have already alluded, is markedly affected by light. The dark brown pigment of the cells, under the influence of light, runs forward in between the rods and cones, so that each rod and cone comes to be isolated from its neighbours by an opaque sheath. Further, we note that the visual purple of the rods of the retina is bleached or destroyed by light. Thus the retina, exposed to light, becomes colourless. But this visual purple does not occur in the cones, which are the only visual cells at the yellow spot. The rays which most affect the visual purple are the lower rays of the visible octave and especially the yellow part of the spectrum. It is this part of the spectrum which most affects our eyes, the opposite being true in the case of the photographic plate. So long as the tenth or pigmented layer of the retina is intact, the visual purple is readily reproduced after its destruction by light.

When Light Falls on the Retina. In attempting to answer the question, "What is the specific action of light on the retina?" several observers have shown—one of them being Professor M'Kendrick, whom we quote—that "when light falls upon the retina it excites a variation of the natural electrical current obtained from the eye by placing it on the cushions of a sensitive galvanometer. The general effect was that the impact of light caused an increase in the natural electrical current; during the continuance of light, the current diminished slowly, and fell in amount even below what it was before the impact, and that the withdrawal of light was followed by a rebound, or second increase, after which the current fell in strength, as if the eye suffered from fatigue."

Professor M'Kendrick goes on to say that "in all probability the electrical change is an index or symptom of certain physical or chemical changes that occur in the retina." Quoting certain other experiments, he goes on to say: "Thus it would appear that light affects the purple matter of the retina, and the result of this chemical change is to stimulate the optic filaments; if the action be arrested, we may have a picture on the retina; but if it be not arrested, the picture is evanescent; the purple matter is used up, and new matter of a similar kind is formed to take its place. The retina might, therefore, be compared to a sensitive plate having the sensitive matter quickly removed and replaced by chemical changes; and it is probable that the electrical expression of these changes is what has been above described."

"Thus Far and No Farther Shalt Thou See." There are naturally imposed and impassable limits to the possibilities of our vision. It may be that, by means of the microscope and the so-called ultra-microscope, large molecules or their shadows may be seen, but it may be taken as absolutely certain that no one will ever be able to see an atom, much less an electron. In other words, the revealing power of the microscope is limited by the nature of light.

Herein is one of the cases where science deliberately asserts that, in a most fruitful direction of research, the very means which are employed by her impose the restriction "thus far and no farther," for, whatever developments are forthcoming in the use of the microscope, the wave-length of light must be reckoned with. The subject has been exhaustively studied by Lord Rayleigh and many other students, and certain very positive conclusions have been reached. It is theoretically possible for two points to be distinguished under the microscope if the distance between them be at least equal to the wave-length of the light that is used.

The Theoretical Limit of Vision. This relation holds with light passing perpendicularly upward through the object examined, if it be transparent; or reflected perpendicularly from its surface to the lenses of the microscope and of the eye, if it be translucent or opaque. With oblique illumination, the inner limit of vision is reduced to half the wave-length of the light employed. Now, a sensitive plate may be affected by rays of wave-length too short to affect our eyes, and hence it follows in theory that the photographic method may reveal minuteness of structure which we can never directly see.

From these considerations, which are not open to dispute, it follows that the theoretical limit of vision—that is to say, of distinguishing distinct objects—is determined by half the shortest wave-length of utilisable light. It may be at present impossible to say at what point light ceases to be utilisable. It is, at any rate, quite certain that we have to pass some distance upward from the wave-length which has the most marked effect upon the retina. The further we pass upward, the greater will be the difficulties with which we have to contend. We may even pass in theory – the practical limit hitherto obtained will be discussed in a moment—to the remarkable rays which were discovered by Professor Röntgen in 1895, and which we are afterwards to consider at length. In all probability the Röntgen rays are absolutely comparable with the rays of visible light, and have the shortest wave-length that we know; in other words, they constitute the very highest notes of the ethereal keyboard.

Röntgen Rays Might Reveal One Eight-millionth of an Inch. The Röntgen or X rays, it is stated, are capable of very faintly stimulating the retina. If only it were possible for us to see directly by them, they would afford us the most intimate microscopic revelation possible—that is, by a microscopic examination of an object obliquely illuminated by them. It has been estimated that their wave length is probably less than one four-millionth of an inch, so that by their use two points under the microscope could be separately identified if there were one eight-millionth part of an inch between them. This indicates very approximately the utmost limit theoretically possible. We are not for a moment asserting that it will certainly ever be more than theory. When we come to study the Röntgen rays we shall see the difficulties involved. The chief reason for estimating the theoretical limit is not by any means that we may suggest its ultimate practicability, but that we may show how remote even this limit is from satisfying the needs of science. Before considering this, let us observe what has so far been accomplished.

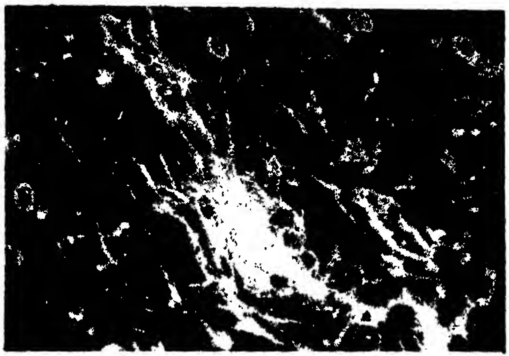
The Most Powerful Microscope. The extent to which the mysteries of Nature have been penetrated by the actual eye of man has been very greatly extended in quite recent years. It would probably be too much to expect, however, that this rate of extension can be continued. In the case of the microscopic method, as in so many others, advance is very often made in the fashion of the man who paid a debt of a shilling, beginning with sixpence, threepence, and so on. The further we go, the slower is the advance, and the smaller the proportion of each step to the total distance to be traversed. The great steps of science are made much less by improvements in old methods than by the invention of new ones. Nevertheless the limits of vision have been greatly extended of late years.

When the *low power* and the *high power* of a microscope are talked about, the first may mean, perhaps, a magnification of fifty diameters, and the second of seven or eight hundred. Then when we hear of the *highest powers*, we find that 1200, or at the very most 1500, diameters are referred to. But it should be more generally known that high-power microscopy has advanced far beyond these limits. [See page 1298.]

Microscopic Value of Light of Different Wave-Lengths. At a conversazione of the Royal Society, the celebrated scientific instrument makers Messrs. R. and J. Beck some years ago showed a remarkable exhibit which illustrated some of the propositions that we have laid down. Its object was to illustrate the ultimate resolving power of the microscope *with light of different wave-lengths.*

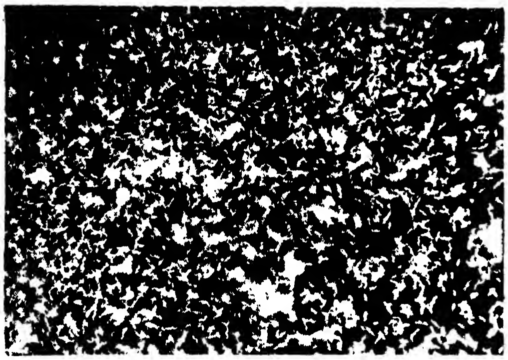
The object examined was an extremely minute atom, and the source of illumination was a Nernst lamp, which yielded a brilliant beam of light. This beam—which of course was compound—was split up by a well-known device into an almost equally brilliant spectrum in such a fashion that any part of the spectrum could be used at will, to the exclusion of the others, for the illumination of the diatom. The apparatus demonstrated that when yellow light was used the diatom was not visible at all, however carefully the instrument was focussed. On the other hand, the details of its structure were perfectly resolved when the green part of the spectrum was employed.

BEYOND THE LIMITS OF HUMAN VISION



AGGLUTINATION OF MICROBES IN THE BLOOD

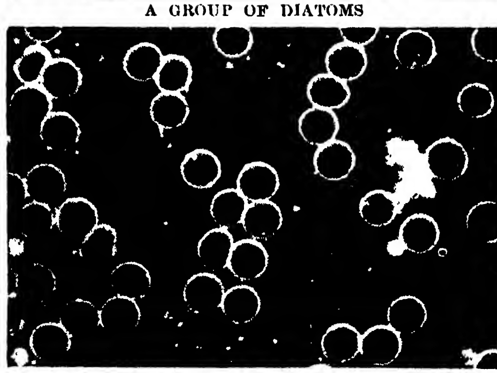
MICROBES IN THE ALIMENTARY CANAL



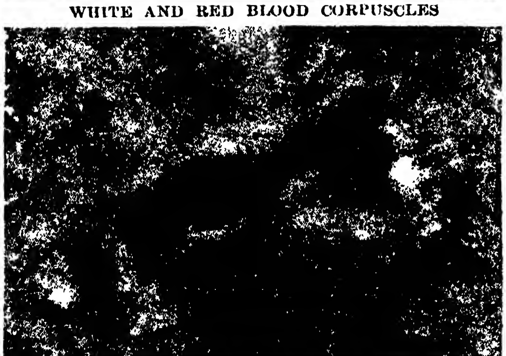
SPIROCHÆTA IN STAGNANT WATER

A GROUP OF DIATOMS

WHITE AND RED BLOOD CORPUSCLES



THE ACTION OF WATER ON BLOOD



"606" VERSUS SPIROCHÆTA PALLIDA

BLOOD CORPUSCLES FORMING ROULEAUX

The development of microscopy in recent years has led to the use of the term "ultra-microscope," as indicating the most detailed view that the improvement in lenses and the ingenious uses of them enable us to obtain of the infinitely small things of life. These pictures are from kinematographs by Messrs. Pathé Frères.

This is an illustration of the law previously mentioned—that the shorter the wave-length, the greater the resolving power of the lens. The green waves are shorter than the yellow waves, and therefore have more resolving power. Shortest of all the waves in the visible spectrum are the violet waves, and they have more resolving power still.

Microscopy by Ultra-Violet Waves. Even yet we have not yet reached the limit of resolution, for beyond the violet end of the visible spectrum we reach yet shorter waves, known as ultra-violet waves, and these, too, can be utilised in microscopy. They are outside the visible spectrum, and do not produce sensation in the centres of vision, but fortunately they do affect photographic films and fluorescent substances, and thus can be indirectly seen and recorded. The violet waves used for this purpose of microphotography are usually produced by an electric spark between magnesium or cadmium wires, and it must be noted that all lenses must be made of quartz, because ordinary glass is opaque to ultra-violet waves.

Photographs and fluorescent screens affected by the ultra-violet waves exhibit details that ordinary microscopic methods fail to discover, both on account of their greater power of resolution and on account of the fact that objects not homogeneous in composition vary in their different parts in their opacity to ultra-violet rays, so that a photograph gives indications of structural heterogeneity, much as an X-ray photograph shows indications of heart and liver and lungs. But X-ray microphotography has not yet been achieved.

Ultra-Microscopy. In recent years the microscope has been put to a very paradoxical use: it has been used to enable us to discover objects which still remain beyond the limits of sight. The ultra-microscopic object is put in a dark microscopic field, and an intense beam of light is focussed obliquely upon it. The oblique beam of light is diffracted by the object, and the diffracted rays, viewed through a microscope, are interpreted by the eye as discs of light.

We see invisible stars through a telescope in exactly the same way on exactly the same principle. We do not see the star; we merely are rendered aware of its existence by the diffracted light that falls upon our retina. Even the planets that we discern by the naked eye are seen only as discs through the light they diffract. The principle of the dark microscopic field is likewise illustrated by the stars, for we see the stars best at night. In the same way, if we pass a beam of light through a dark room, we see shining motes, many of them ultra-microscopic, which we do not see in diffuse daylight. Naturally shining objects show best against a dark background.

Ultra-microscopy by oblique light has revealed many ultra-microscopic objects to us. Ruby glass, for instance, is coloured by the addition of minute quantities of gold, and the gold is dispersed through the glass in particles far too infinitesimal to be detected by the microscope, and yet by the ultra-microscodic method the particles can be clearly seen as shining stars. Again, in certain colloid solutions the motions of particles which are far beyond the reach of direct vision can be clearly seen. Also, germs invisible by the ordinary microscope, and small enough to pass through a Chamberland porcelain filter, can be detected.

Microkinematograph Pictures of Germs. By the ultra-microscopic methods the size and shape of ultra-microscopic objects cannot be judged, but the shapes of objects just large enough to be seen by the microscope are quite well shown; and lately, by a combination of ultra-microscopy and kinematography, *microkinematographs*, showing the movements of living germs, have been successfully prepared. The war between the white blood corpuscles and microbes in the blood can be clearly exhibited. If mobile microbes are under observation, they may be seen swimming about in the blood, and the white blood corpuscles can be seen enveloping them and devouring them. The *Spirochæta pallida*, that terrible enemy of man that has slain its millions, and that can be seen with great difficulty by ordinary microscopic methods, is revealed quite distinctly in microkinematograph pictures—little, delicate, corkscrew-like bodies, small almost beyond imagination, and yet infinitely more lethal than the sword or bayonet.

Use of Oil in Magnification. One other refinement in the use of the microscope—it is older than those we have just mentioned, but is extremely important. If we did not mention it the reader might be puzzled when he met such a phrase as *oil immersion lens*. When even approximately high powers of the microscope are employed, a drop of clear oil is placed upon the slip of glass which covers the object. The object-glass of the instrument is then lowered so as to be actually immersed in the drop of oil. Originally, the method employed consisted in the introduction of a drop of water. This diminished the loss of light which occurred as the rays passed from the cover-slip to the object-glass, and had various other advantages as well. But now we use a drop of oil, in accordance with the work of the most remarkable man who ever concerned himself with the microscope, Professor Abbe, of Jena, the scientific adviser of the famous firm of Zeiss. [See page 1157.]

The oil employed is the oil of cedar-wood, which has the same refractive and dispersive powers as crown glass, with the consequence that "the rays issuing at any angle from the upper plane surface of the covering glass shall enter the plane front of the objective without any deflection from their straight course and without any sensible loss by reflection." The introduction of the oil, or "homogeneous system," has immensely advanced microscopy, and affords a very conspicuous instance of the advantages which ensue when the highest scientific intelligence is associated with the highest commercial intelligence. C. W. SALEEBY

The Various Types of Kilns. Their Operation and Merits Considered. The Modern Rotary Kiln.

CEMENT BURNING & GRINDING

WHEN the raw materials have been finely and intimately mixed, either in the shape of slurry by the wet process or as raw meal in the dry process, they have to be subjected to a "calcination" or burning at a high temperature.

The rotary kiln, which is now being generally introduced for this purpose, has, among other advantages, that of taking the raw materials in the shape in which they come from the raw mill, whether as slurry or raw meal, direct to the calcining operation, whereas all forms of kilns hitherto used do not allow of this. The slurry or raw meal in the old process has to be brought into the shape of lumps or bricks before it can be charged into the kilns. It is, therefore, necessary to mention here the different ways in which this can be done.

Burning Cement in Brick Form. Mention has already been made of the various processes of plastic brickmaking by mixing slurry and raw meal in different forms. Plastic bricks can also be made from raw meal by simply adding sufficient water to bring it to a suitable consistency for treating in a pug mill and brick machine. This will amount to 20 to 25 per cent., according to the nature of the raw materials.

The resulting plastic bricks must be dried by one of the methods already mentioned, such as tunnel dryers.

Bricks can also be made by adding only a small amount of water—say 5 to 15 per cent.—according to the nature of the raw materials, and subjecting this mixture to a very heavy pressure in so-called *dry presses*, of which a number of forms are in common use—such as toggle-joint presses, hydraulic presses, and hammer presses. In BRICKMAKING [page 1800] we have described both Johnson's and Whittaker's toggle-joint presses. In the hammer press the moist raw meal is pressed into brick-shape by heavy falling weights. The resulting dry-pressed bricks can be either dried, or else charged into the kiln in the semi-dry state. The choice of method depends on the kiln used.

Another way of making bricks which must be mentioned here, as it is frequently used in those English cement works where the raw material is blue lias lime, consists in adding a considerable quantity of water to the raw meal obtained in the dry process and pugging this in a pug mill, so as to form a semi-fluid paste, which is spread on drying floors. It is cut into squares in a half-dried condition, which, when dry, can be loosened from the floor and form bricks for charging direct into the kilns.

How to Dry Slurry. To get slurry to the right consistency for the kilns all that is necessary is to spread it in layers of suitable thickness on drying floors, and, after drying, break it up into lumps, which can be charged into the kiln.

In some places the slurry is cut into squares before it becomes quite dry; this is the method adopted in those works using blue lias lime.

General Remarks about Kilns. The temperature to which the raw materials must be subjected in order to bring about the necessary chemical changes is a very high one, but does not vary very much. To measure these high temperatures with any degree of accuracy is a difficult and uncertain operation, but it is generally assumed that the temperature in a cement kiln is about 1,500° to 1,600° C. On the other hand, the process is practically instantaneous—that is to say, as soon as the necessary temperature is obtained, the chemical changes take place at once, and the process is finished. The carbonic acid gas contained in the raw materials will have been driven out gradually before this high temperature is reached.

A great number of kilns of very varying type and construction have been used. They fall naturally into two main divisions, the *periodical* and the *continuous* kilns. The former are charged with the fuel and raw material, fired and allowed to burn out completely, and to cool down before they are emptied. This process is always repeated in the same manner. The continuous kilns, when in full fire, are continuously emptied and re-charged by gradually discharging clinker at one end, and reloading with fuel and raw material at the other. Compare similar classes of kilns used for lime burning [page 1939].

The Bottle Kiln. This is the oldest type of kiln, and consists of a round or square chamber built of bricks, and lined inside with fire bricks. A continuation of the upper part in much thinner brickwork forms a chimney. Above the top of the kiln, at the base of the chimney, are situated one or more "loading" eyes, that is to say, openings in the brickwork for the admission of the charge. The chamber or bowl of the kiln at the bottom is provided with a grating, either of iron or of perforated brickwork, and underneath are the "draw-eyes" for removal of the clinker. The kiln, when emptied, is charged first with faggots or shavings, and above this with a layer of coke. On top of these the kiln is filled up with alternate layers of raw material and coke. When the loading is finished, the kiln is fired from below and allowed to burn out and cool. This process, as a rule, takes about five days, more or less, according to the size of the kiln. The capacity

of a kiln varies from 10 or 15 tons up to 50 tons of finished clinker.

It may be here stated that bottle kilns have also been built of much larger dimensions for continuous burning; but we shall consider them later on.

The Chamber Kiln. The invention of this type of kiln is generally attributed to J. C. Johnson, the first to manufacture Portland cement on a large scale, and is known as the Johnson chamber kiln. As a rule, it is used in connection with the wet process, but, in a few instances, for the dry process also. In either case, it consists in the addition of a long horizontal chamber flat on the bottom, with an arched roof, leading from the burning chamber or bowl of the kiln to a chimney or flue. The object of this chamber is to utilise the waste heat leaving the burning chamber to dry the charge of materials for the next burning. For this purpose, sufficient slurry for one charge is pumped up on to the flat floor of the drying chamber, or a corresponding quantity of raw meal bricks stacked in the chamber, so that the heat given off from the products of combustion in the kiln passing through the chamber, drives the moisture out of the raw materials deposited there.

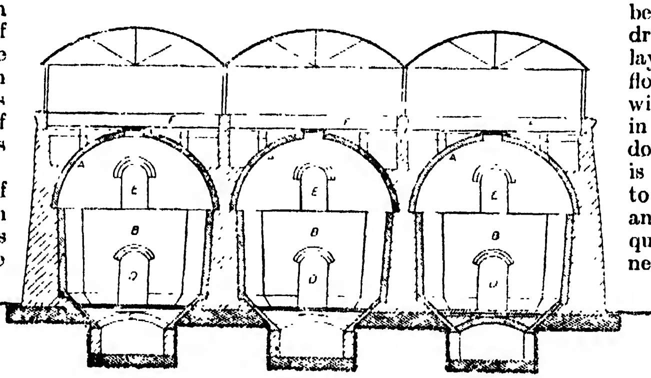
Many forms of kilns have been evolved from this simple type, the chambers having been made of different shapes and lengths. Sometimes several chambers are arranged beside or above one another, in other forms both the arches have been substituted partly or entirely by floors constructed of iron plates.

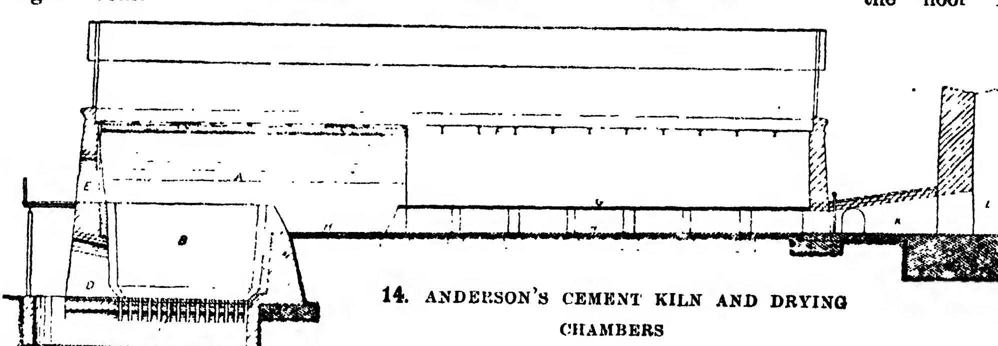
As an example, we give in **14** an illustration which at the same time shows the Anderson patent drying chambers.

Old Kilns brought up to Date. We are dealing here with old chamber kilns which have been altered to improve the drying chambers so as to increase the drying capacity. It will be seen that the arches A, which before the alteration extended right away through the whole length of the kiln, have been taken down, except over and just beyond the burning chamber of the kiln B. This burning chamber is usually lined with firebricks, and has a fire-brick grating (C), supported by an arch at the bottom. Access to the lower part of the burning chamber is gained through a doorway (D), which, during the burning, is closed by a temporary brick wall. This doorway also serves as a draw-eye for removing the clinker when the kiln is burnt off. Another door (E), connects the top of the burning chamber with the gangway outside, through which the fuel is brought into the kiln. The chamber is covered over by a floor (F) of wrought-iron joists supporting cast-iron plates extending throughout the whole length of the chamber, including that portion which is arched over. An intermediate floor (G), consisting of cast-iron plates resting on longitudinal girders resting again on brick piers is arranged a little way over the bottom of the chamber H.

Charging the Kiln. The burning chamber is charged with dried slurry in layers from the floors G and H, and with fuel brought in through the doorway E. Slurry is then pumped on to the floors G and H in sufficient quantity for the next charge of the kiln. An additional quantity of slurry is pumped on to the floor F, and this slurry, after drying, can be burnt in separate kilns, as, for instance, in Schneider kilns.

When the charging of the burning chamber and drying floors is completed, the kiln is fired. The waste heat arising from the burning clinker has room to expand freely up under the arches A and the floor F. The products of combustion are drawn off by the chimney stack L, through the flue formed between the two floors G and H, and a continuation of this in the shape of an





14. ANDERSON'S CEMENT KILN AND DRYING CHAMBERS

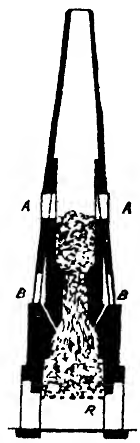
arched flue (K). The draught is regulated by the damper I.

The outside drying floors F, are covered over by suitable roofing to keep the rain away from the slurry.

When the kiln is burnt off, some of the plates in the floor F are lifted and left open to get the inside of the kiln cooled as quickly as possible. For this purpose a couple of openings (M), in the arches, are also made, and these openings are provided with removable firebrick covers.

We have gone into this subject because it illustrates an easy means by which cement works having the old-fashioned chamber kilns can obtain more economical results with the assistance of one of the modern continuous kilns working with dried raw material.

It is possible, with the help of improved drying chambers, to let the old-fashioned chamber kiln not only dry sufficient material for its own use, but a very considerable surplus, which can then be burnt very cheaply in the more modern continuous kiln. In this way we may effect a saving on the whole output, which in several cases has been shown to amount to 2s. per ton.



15. THE AALBORG KILN

Continuous Kilns. All these kilns may be said to consist of a long channel or a series of burning chambers forming together a long channel. This channel can be vertical or horizontal; it can be built in the form of a straight line, the two ends being wide apart, or it can be bent so that the two ends meet and form one continuous channel.

The Hoffmann Kiln. The Hoffmann kiln is an illustration of this latter principle. A form of this kiln has already been described in BRICKMAKING [page 1804]. The burning channel consists of two straight tunnels side by side, and united at both ends; a number of doorways lead through the outside brickwork, and give access to the burning channel for charging the kiln with raw bricks and for removal of the clinker. The channel is arched over, and, as a rule, deflecting arches are inserted between each pair of doorways, dividing up the burning channel into several chambers. In the process of burning, the chambers in front of the fire are separated from each other by a cross partition formed of stout brown-paper pasted on. The fire progresses from chamber to chamber, and travels round the channel continuously. A certain number of chambers behind the fire are always cooling, while others in front of the fire are drying. The drying is effected by leading the products of combustion from the chambers under fire through those where the drying is in progress on the way to the chimney, which is situated at one end, and is connected with all the chambers by a main flue running round in the brickwork just outside the burning channel. The chambers are also connected with each other through a flue in the centre, so that the heat can be led from any one chamber into any other, and then away to the chimney.

It will be evident that on the opposite side of the kiln to where the firing is in progress, the chambers will be coolest. The clinker is drawn out, and raw bricks stacked in this coolest chamber.

The Hoffmann kiln has been used to a very considerable extent in the dry process works on the Continent, but has hardly ever been used in connection with the wet process, and has never found much favour in England for cement burning.

Continuous Vertical Kilns. The bottle kiln has already been mentioned above; very large bottle kilns are fired continuously. When the kiln is loaded and fired in the usual manner, and the fire has reached a certain level somewhere near the top, clinker is drawn out at the bottom, and after the charge has "set," fresh layers of coke and raw material are charged on to the top of the old charge. In this way the process works continuously. Several modifications of this system have been largely employed, and among them the use of the Schneider kiln has found great favour in England in connection with chamber kilns with improved chambers, which are able to dry a considerable surplus of slurry, besides what they themselves require.

As already mentioned above, the usual drawback to the continuous bottle kiln is the difficulty in obtaining the regular setting of the kiln—that is to say, the regular sliding action of the charge downwards; the clinker tends to bake on to the firebrick lining of the kiln, and thus prevents the setting. When this happens, the charge will hang on one side, and the setting becomes irregular, interfering with the systematic charging in of layers on to the top. Under such circumstances, a great deal of half-burnt clinker is generally formed, and the burning is unsatisfactory in every way. In the Schneider kiln this is prevented by a special loading arrangement allowing the firebrick lining to be separated from the charge, or rather from the fuel, protecting the firebrick lining with a layer of raw material of such thickness that it will only just be calcined without any danger of its baking on to the sides of the fire bricks.

Continuous and Periodical Kilns Compared. The working of a continuous kiln of this type as compared to the working of the ordinary chamber kiln shows a very great improvement in output and cost of production. Taking an average sized chamber kiln, with an output of 30 to 40 tons for each burning (which takes about five days), the kiln will only produce about 40 to 50 tons per week. The Schneider kiln with dry raw materials will produce from 80 to 100 tons, or just twice the quantity, and the fuel consumption which in the chamber kiln averages 8 cwt. of coke per ton of clinker burnt will in the Schneider kiln be less than 4 cwt. However, it is only fair that we should remember

that the chamber kiln effects the drying not only of its own slurry, but also of that burnt in the Schneider kiln, and it does not cost anything extra to have this surplus dried by the chamber kiln. Four chamber kilns of the size above mentioned, with properly arranged drying chambers, will be capable of drying sufficient slurry to keep one Schneider kiln going, and their united capacity will be 50 per cent. more than the capacity of the original kilns.

A Modern Vertical Kiln. Another form of vertical continuous bottle kiln is the Aalborg kiln which we owe to Shœfer and Smidth. An illustration of this kiln will be found in **15**. The raw materials, either dried slurry or bricks, must be quite dry before being charged into the pre-heater through the charging doors A. All the fuel is charged into the centre of the kiln through a number of shoots (BB), built into the firebrick lining of the kiln half-way down between A and the grating R, and the burning takes place mostly in the conical-shaped burning chamber, where these shoots enter the kiln. In the chamber below, the clinker cools and the charge is gradually heated in the narrow neck and pre-heater above by the waste heat from the burning. The economy in fuel in a kiln of this construction has been brought to a maximum. The consumption of coal on an average is rather less than 3 cwt. per ton of cement produced, and common small gas coal can be used as fuel instead of coke.

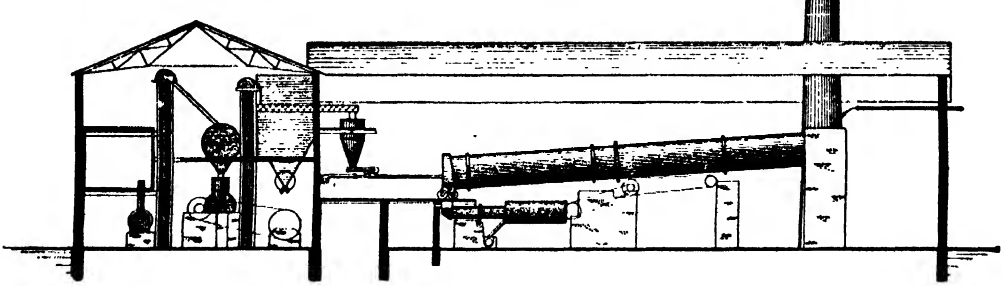
On the other hand, the burning of these kilns requires a considerable amount of skill.

The kiln has found much favour in America and on the Continent, and also in our Colonies, but not much in England itself.

The Latest Type—the Rotary Kiln. In all the kilns we have so far mentioned it will be seen that the raw materials—whether made on the wet or on the dry process—must be loaded into the kiln in the form of bricks or lumps. None of these kilns has been adapted for receiving the raw materials in the shape of a dry powder or a wet slurry, though some of them have been arranged to utilise the waste heat from one burning to dry the necessary charge for the next. Even in these cases, however, the material has to be handled after being dried.

The idea of constructing a furnace which would receive the material either as a dry powder or as wet slurry without further handling, and convert it into clinker in one operation, is a very tempting one. This is what the rotary kiln actually accomplishes.

Original Rotary Kilns. The history of its discovery and development need not detain us long. The first records are to be found in the patent registers as far back as 1877, when Thomas Russel Crampton, who had in the preceding year patented a revolving furnace for roasting ores, extended the application of his invention to cement. His kiln does not seem, however, to have been heard of since then, and in 1885 Frederick Ransome patented practically the same thing, but in a rather better form, and several kilns were built and worked. They were all abandoned before very long, as the coal consumption was found to be extravagantly high, probably because the kilns were much too small and could not utilise the fuel properly.



16. GENERAL PRINCIPLE OF A ROTARY KILN

The principle of all continuous kilns is well illustrated in the Aalborg. It consists in utilising the waste heat in the kiln itself. The actual burning takes place in the middle, and this part of the kiln is supplied with hot air which has passed over the cooling clinker underneath, while the hot gases from the burning clinker passing up give a preliminary heating to the raw material above in the upper part of the kiln before it reaches the intensely-heated middle portion.

As the burning of the fuel takes place with access of large quantities of very hot air, the burning is very complete, and the fuel is utilised to the utmost. At the same time practically no waste heat leaves the kiln.

The next we hear of the rotary kiln is in the United States, where kilns of a practical size—60 ft. long and 5 ft. in diameter—were introduced.

Originally they were intended for burning cement by means of mineral oil, but the application of the kiln was soon extended, and it was used both for wet and dry material, and was fired by coal dust or natural gas as well as oil. The use of coal dates back only to about the year 1897, as before this kilns using liquid fuel only were worked in America.

Principle of the Rotary Kiln. The principle of the rotary kiln is illustrated in **16** and **17**, and is extremely simple. The kiln consists merely of a long, straight cylinder, which is

made to revolve slowly by means of live rings on roller bearings and a suitable driving gear. The kiln is not quite horizontal, but erected with a slight incline, so that the material moves slowly downwards actuated by the force of gravity.

At the upper end the cylinder enters into a brick-built chamber, and on this, or on another brick-built chamber connected with the first, a chimney is placed to carry away the products of combustion.

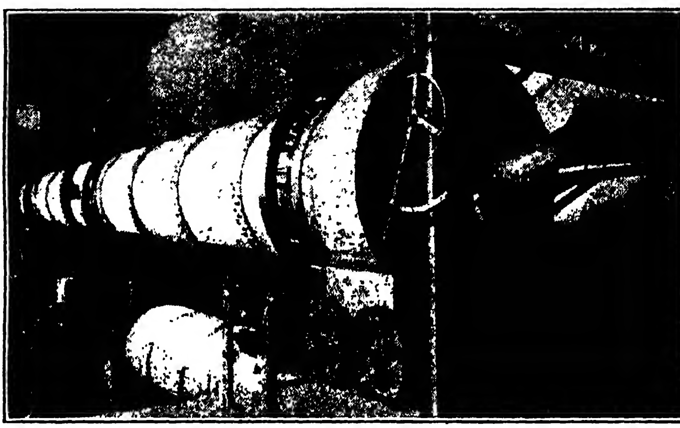
The lower end of the kiln is closed either by a fixed wall or a movable hood clearly seen in **17**, with an opening at the bottom, through which the clinker falls out. The cylinder is lined entirely or partly with firebricks in order to protect the iron shell from the excessive heat and wear arising out of the quantity of hot clinker moving down it, and also to keep the heat better in the kiln by preventing too much radiation through the shell.

The speed of rotation varies somewhat, but it is rarely more than one revolution per minute, and usually less. The dimensions, which originally were at most 60 ft. in length by 5 ft. in diameter, have gradually been increased and are now commonly 120 ft. in length and 6 or 7 ft. in diameter. At Edison's Cement Works in Stewartsville, U.S.A., cast-iron kilns, made of pipes joined together by flanges have been made 150 ft. long and 9 ft. in diameter, and these, are, so far, the biggest kilns that have ever been constructed.

Clinker Coolers and Utilisation of Waste Heat. In connection with the lower end of the kiln a clinker cooler is commonly used. This is not absolutely necessary, and in many American works the clinker simply drops on to the floor or into a steel wheelbarrow and is carried outside and spread on the ground to cool. In other American works the hot clinker as it falls out of the kiln is elevated by a strong chain-bucket elevator to the top of a cylindrical cooling tower. This tower is sometimes provided with artificial draught to cool the clinker, which then falls out at the foot of the tower, and is thence taken away to the mill.

In modern practice, however, a revolving clinker cooler is generally used, although the type of machine is subject to considerable variation.

The clinker cooler is seen under the kiln in **17**.



17. AN UP-TO-DATE ROTARY KILN, SHOWING AIR BLAST AND COAL DUST SUPPLY PIPES

In the Hurry & Seaman kilns the rotary kilns themselves are laid in pairs, each pair having three coolers so arranged that two of the coolers take the clinker from the two kilns and bring it together into the third cooler, whence it is finally discharged quite cold. These coolers lead away from the kiln, so that the material from start to finish travels in the same direction.

In most of the other systems, however, the coolers are built under the kilns, so that the material in the cooler travels in the opposite direction to that in the kiln.

Smidth's cooler, seen under the rotary kiln [**16**], consists of two cylinders, one inside the other, and the material travels first in one direction inside one, the inner one, and then in the opposite direction outside it but inside the outer one. The object of this is to heat the air, which by natural draught or by the assistance of a fan passes through the cooler. This air current cools the clinker and the air is made as hot as possible when it leaves the cooler to enter the kiln. The combustion of the fuel will be greatly assisted by hot air, the hotter the better.

The revolving cooler is constructed of iron plates and fitted with running and driving gear of the same nature as that used for the kiln itself.

Firing the Kilns. In some places in America natural gas has been used, and in very few cases water gas or producer gas. In such cases the firing device is very simple, consisting of a gas pipe with the necessary means for regulating the jet.

Oil has been and is used to a large extent, especially in the United States, where in many parts it is extremely cheap.

The oil flows from a tank under a certain pressure, and passes out from a special injector or nozzle. It is thus reduced to a form of spray, sometimes assisted by steam jets placed underneath the oil jets, or connected directly with them.

By far the most general way of firing the kiln, however, is by means of powdered coal.

To grind the coal sufficiently fine it is, as a rule, necessary to dry it first, and for this purpose we naturally utilise some of the waste heat from the kiln. We can arrange the plant to dry the coal by bringing it directly into contact with the lower hot end of the kiln itself, either by partitioning off the brickwork, a hopper-shaped room through which the kiln passes, or by

surrounding the kiln with a mantle and passing the coal through the room between this mantle and the shell of the kiln. Another way to dry the coal consists in passing the coal through a drying drum heated by means of the hot air from the clinker cooler on its way to the kiln.

Grinding coal is a simple matter, and several classes of grinding machines are found suitable. The coal dust is delivered from the drying and grinding plant into a hopper with an extracting worm, where a sufficient quantity for several hours' working is always stored, so as to avoid the danger of stopping the kiln in case of a slight mishap in the coal mill. From the bottom of this hopper the coal dust is extracted by a worm provided with an appliance for regulating accurately the quantity of coal dust fed into the kiln. From this worm it is dropped into a nozzle, through which a strong current of air from a blast fan is driven. The coal dust mixes with the air, and is carried along with it to the centre of the lower end of the kiln.

In **17** the firing end is the near end. The narrow pipe shown is the coal dust feed pipe. The large one is the hot air feed pipe. The end of the cylinder is formed of a movable hood, which can be taken away for cleaning purposes. The lever handles seen in the front are for regulating the feed of raw material at the other end of the kiln. The circular rack about half-way down the kiln is part of the machinery which causes the kiln to revolve.

The Inlet for the Raw Material. This is extremely simple in construction, the dry meal being fed from a hopper by an adjustable feed arrangement, through a shoot, and direct into the kiln. Sometimes a small quantity of water is added to it in a mixing and moistening machine before feeding into the kiln, to prevent the fine flour from being carried away by the draught of the chimney.

If the raw material be in the form of slurry it is fed into the kiln through a pipe, means being provided for a constant pressure, or head of slurry, and the inlet pipe to the kiln having a valve for regulating or stopping the flow.

Output of the Rotary Kiln. The results obtained by the rotary kiln are very different in several respects from those obtained by any other system of kiln. The clinker is much more regularly burnt, and, as a rule, of more regular shape. It leaves the kiln in the form of small, round lumps, sometimes conglomerated into masses, and rarely exceeding the size of a small egg, whereas the clinker formed in other kilns consists of large vitreous and spongy lumps. The rotary kiln clinker is much harder to grind than the ordinary clinker.

The output from one rotary kiln of the ordinary size—say, 100 ft. long and 7 ft. in diameter—is about 50-60 tons per day when burning raw meal, and 35-40 tons when burning slurry.

The coal consumption is not so low as with some of the more economical continuous shaft kilns. With raw meal it may be said to vary between 4½ and 5½ cwt. per ton of clinker produced; and with slurry, between 5 and 6 cwt., according to the quality of the coal and the nature of the raw materials. It must, however, be remembered that the fuel used is coal, whereas, with very few exceptions, coke is required in the other systems of kilns.

The labour in the rotary kiln is naturally reduced to a minimum. There is practically no actual labour required, but there must, of course, be a burner to take charge of the kiln. He regulates the feeds of raw material and fuel, and looks after the kiln in a general sort of way. As a rule, each kiln has a burner who is responsible for its working, but where labour is very expensive it is quite possible for one man to look after two or even three kilns.

Crushing and Grinding Cement. Until comparatively few years ago, millstones were commonly used for finishing cement clinker, after it had passed a stone crusher or crushing rolls. With the increasing demand for finer grinding, however, millstones have proved too expensive, not only in respect to the power required to drive them, but also in upkeep.

The old specification of fineness was such that 10 per cent. residue was allowed on a mesh No. 50 containing 2500 holes per square inch. Nowadays the specifications are far more stringent, as will be seen later when we consider the testing of cement.

To grind to such a fineness with millstones would be quite impracticable; with the increasing fineness the stones must be pressed tighter together; the output from each pair of stones will consequently fall quicker, while the power consumed at the same time rises very rapidly. Besides this, the stones must be dressed much more frequently, and the expense involved becomes excessive.

Merits of Mills. For a long time ball mills were used to a considerable extent as finishing grinders, but with the demand for increasing fineness in grinding, the gauze through which the ball mill discharges the finished product had to be made so fine that the cost of repair on the delicate screens ran very high. The introduction of the tube mill, and the division of the grinding into a preliminary coarse grinding, and a finishing fine grinding effected by this machine, made the fine grinding an easy and inexpensive matter. [See page 2077.]

The grinding of cement differs from that of the raw materials only in so far as the cement is a much harder substance, although this in itself does not make much difference in the grinding operation. The hardness of the clinker varies considerably, and the output which can be obtained by mills of a certain size is therefore very variable. As a rule the clinker burnt in ordinary bottle kilns, either periodical or continuous, is so much softer than that burnt in the rotary kiln that when a set of machines can reduce six tons per hour of an average bottle kiln clinker, the same machines will sometimes treat only four tons of a hard rotary clinker when grinding to the same fineness.

CLAYTON-BEADLE and H. P. STEVENS

Flying and Running Birds, Grouped into their Orders. Song Birds, Pigeons, Gulls, Game Birds, Eagles, and Aquatic Birds.

THE CLASSIFICATION OF BIRDS

Birds are vertebrates with hot blood (103° F., distinctly higher than in mammals), and by the possession of feathers, and the alteration of their fore-limbs into wings, are clearly marked off from all other animals which now exist, though they resemble reptiles in many ways, and are undoubtedly derived from the same ancestral stock. The digits of the hand have been reduced to three, by loss of the fourth and little fingers, and there are never more than four toes in the foot, the little toe being always absent. No existing bird possesses teeth.

There are some 10,000 living species (as against under 3000 mammals), which fall into two sub-classes—flying birds (*Carinatæ*) and running birds (*Ratitæ*).

FLYING BIRDS

The flying birds include the vast majority of forms, and it is a difficult task to subdivide them into smaller groups, for the differences between them are often comparatively trivial, and it is impossible to draw the sharp boundary-lines which we have seen to exist in mammals. The older naturalists relied solely upon structure as obviously related to habits, and spoke of swimming, climbing, wading, scratching, perching birds, etc., but this method of classification is now considerably modified, for it brings together some species which only resemble one another in a very superficial way, and separates others that are nearly related. There are a very large number of families grouped into orders; and it will here only be possible to give a very brief review of some of the more important of them, omitting extinct forms, which are dealt with separately.

Order 1. Perching Birds (*Passeres*). The large order of perching birds, which is admittedly the highest, includes more than half (some 5500) of the known species, and the bulk of British "small birds" are referred to it. The four-toed foot is adapted to perching, that is, firmly grasping boughs and the like, in accordance with which the backwardly directed great toe bears a comparatively large claw and possesses unusual powers of free movement. This type of foot may be studied in a tame canary. The young are helpless, almost naked, nestlings.

The "song-birds" (*Oscines*), with some of their close allies not specially remarkable for vocal powers, head the long list of perchers. It is interesting to note that the "song-box" (*syrinx*), which is the source of melody, does not correspond to the "voice-box" (*larynx*) of mammals, for it is situated where the windpipe forks into a branch for each lung, while the voice-box is the modified top of the same.

Finches and buntings (*Fringillidæ*) are small birds with a strong, conical beak, well able to deal with seeds or with a mixed diet. The following are familiar British forms: Goldfinch (*Carduelis elegans*), chaffinch (*Fringilla cœlebs*), bullfinch (*Pyrrhula europæa*), linnet (*Linota cannabina*), yellow-hammer (*Emberiza citrinella*), and house-sparrow (*Passer domesticus*). In the less common crossbill (*Loxia curvirostra*) the upper and lower halves of the beak cross each other in scissor-like fashion, an arrangement which facilitates the extraction of seeds from the cones of pine, fir, larch, and the like.

The American starlings (*Icteridæ*) possess longer and narrower beaks than the finches, and are interesting because they include the cow-birds (*Molothrus*), some of which, like cuckoos, deposit their eggs in the nests of more industrious songsters. One South American species (*M. rufoaxillaris*) takes advantage in this way of an allied species (*M. badius*), which constructs a nest in the orthodox fashion.

Weaver-birds (*Ploceidæ*), most of which are African, though the family ranges east to Australia, are remarkable for the way in which they weave stalks and fibres into rounded nests with tubular entrances. The most familiar form seen in captivity is the Java sparrow (*Munia oryzivora*). The creepers (*Certhiidæ*) are represented in this country by the active little tree-creeper (*Certhia familiaris*), which may often be seen making its way up mossy walls and tree-trunks, searching for insect food with its slender curved beak, and using its stiff tail-feathers as a support.

The beautiful little sun-birds (*Nectariniidæ*), which range through the hotter parts of the Old World, are often mistaken for humming-birds, owing to their brilliant metallic plumage and long, slender beaks. They render valuable service to many plants by transferring pollen.

The starlings (*Sturnidæ*) are chiefly to be found in Africa and India, but are represented in most parts of the Old World, and the common starling (*Sturnus vulgaris*) is familiar in this country. It is even to be seen so far north as Greenland. The long, pointed beak deals with animal food, but some species also eat fruit and seeds. In Africa, the ox-pecker (*Buphaga*) devotes its attention to the ticks which infest cattle and other mammals.

The stout-billed crows and allied forms (*Corvidæ*) are represented in almost all parts of the globe, and their food is of miscellaneous character. The best-known British species are the raven (*Corvus corax*), carrion crow (*C. corone*), rook (*C. frugilegus*), jackdaw (*C. monedula*), magpie (*Pica rustica*), and jay (*Garrulus glandarius*).

The birds of paradise (*Paradiseidæ*) of the Australian region, despite their beautiful plumage,

TYPICAL BIRDS OF THE BRITISH ISLANDS

CAPERCAILLIE

CUCKOO

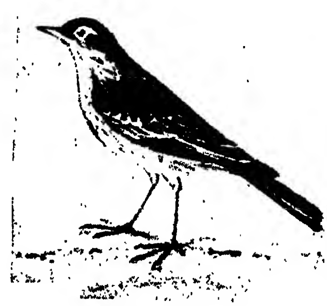
BLACK GROUSE

HOOPOE

YELLOW WAGTAIL

GOLDEN PLOVER

PEEWIT, OR LAPWING



MEADOW PIPIT

WATER-OUZEL, OR DIPPER

GOLDEN-CRESTED WREN

BEE-EATER

COMMON SNIPE

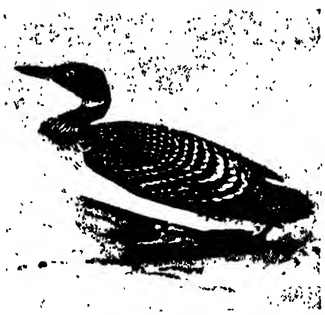
BIRDS THAT HAUNT BRITISH SEAS & RIVERS

COMMON CORMORANT

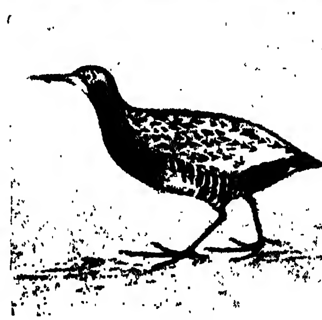
COMMON GUILLEMOT

GREAT AUK

MOORHEN

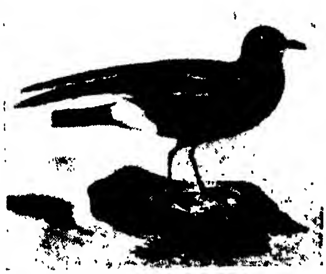


GREAT NORTHERN DIVER



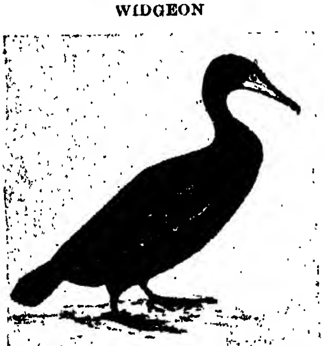
WATER-RAIL

WIDGEON



STORM PETREL

GREAT-CRESTED GREBE



SHAG, OR GREEN CORMORANT

PUFFIN

ARCTIC TERN

are closely related to the crows. Grouped with them are the more sober-plumaged bower-birds, some of which are famous for the way in which they construct "bowers" for purposes of play, or even a "garden," which is made gay with flowers and berries, renewed as soon as they fade.

The pretty little insectivorous tits (*Paridæ*) are almost cosmopolitan, and haunt trees in search of their food. The blue tit (*Parus cæruleus*) is, perhaps, the prettiest of our native species. The bearded tit (*Panurus biarmicus*) is now placed in a family of its own (*Panuridæ*).

Nut-hatches (*Sittidæ*), represented in Britain by the common nut-hatch (*Sitta cæsia*), resemble tits in habit, but are of somewhat larger size. Shrikes (*Laniidæ*) have strong bills, often strongly hooked in relation to their carnivorous diet. Our commonest species is the red-backed shrike or "butcher-bird" (*Lanius collurio*). The latter name has reference to the curious practice of impaling all sorts of small creatures near the nest, to serve as a "larder."

Swallows and martins (*Hirundinidæ*) are to be found practically all over the world, and furnish the most obvious British example of migratory species. Their marked powers of rapid flight, enabling them to catch insects on the wing, are associated with long, pointed wings, and a well-developed tail, often deeply forked. The short, broad beak can be opened very widely to receive the insect victims. The feet are small and feeble. There are three British species, the swallow (*Hirundo rustica*), with reddish throat and deeply forked greenish tail, the white-throated martin (*Chelidon urbica*), and the sand-martin (*Cotile riparia*), which nests in sandbanks.

The wrens (*Troglodytidæ*), though very widely distributed, are most characteristic of the hotter parts of America. Our little native wren (*Troglodytes parvulus*), with its short, upturned tail, is often to be seen in hedges, using its slender pointed bill for the capture of insects and other small creatures, when these are to be had. In winter it largely feeds on fruits and seeds.

The water-ousels (*Cinclidæ*), which look something like stoutly built wrens, frequent rapid upland streams, in which they dive for insects and small molluscs. Our native dipper (*Cinclus aquaticus*) belongs to the family.

The thrushes, warblers, and mocking-birds (*Turdidæ*) make up a cosmopolitan family, including many familiar forms, some of which are noted songsters. Among British species are the following: Song-thrush (*Turdus musicus*), blackbird (*T. merula*), wheatear (*Saxicola œnanthe*), robin (*Erithacus rubecula*), nightingale (*Daulias luscinia*), garden warbler (*Sylvia hortensis*), golden-crested wren (*Regulus cristatus*), our smallest native bird, and hedge-sparrow (*Accentor modularis*). The mocking birds are American forms.

Wagtails and pipits (*Motacillidæ*) are among our best-known small birds. The former are typically Old World forms, distinguished by the jerky way in which they move their long tails up and down. Our commonest species is the water-wagtail (*Motacilla lugubris*), but the yellow wagtail (*M. raii*) is locally abundant. The shorter-tailed pipits are practically cosmopolitan, and are represented in Britain by a number of species of which the meadow pipit (*Anthus pratensis*) is typical.

Larks (*Alaudidæ*) are mostly Old World forms, generally distinguished by the long, straight claw of the great toe. The only species which nest in this country are the skylark (*Alauda arvensis*) and woodlark (*Lullula arborea*).

There are many other families of perchers, but as none are represented in Britain mention of them will be omitted here, though allusion may be made to some of them in the sequel.

Order 2. Woodpecker-like Birds. (*Picariæ*). Here are included a large number of short-legged birds, which mostly dwell in trees, and commonly make their nests in holes. As in perchers, the young are helpless nestlings.

Woodpeckers (*Picidæ*), as represented by the most typical members of the family, possess climbing feet, in which the fourth as well as the first toe is directed backward. The stiff tail-feathers also serve as a support. The powerful beak is well suited for breaking open rotten wood in search of insects and their larvæ, while the wormlike tongue is capable of an extraordinary degree of protrusion. Covered with glutinous saliva, it easily secures the prey, aided by its hard, barbed tip. The commonest British species is the green woodpecker (*Gecinus viridis*).

The brilliantly coloured toucans (*Rhamphastidæ*) of South America are distinguished by the possession of an enormous beak, greatly flattened from side to side. In a wild state they are supposed to live chiefly on fruits and seeds.

Of barbets and honey-guides (*Capitonidæ*) the former are somewhat clumsy birds of bright plumage, well represented in the tropics, but the chief interest of the family is centred in the honey-guides, native to Africa, the Himalayas, the Malay Peninsula, and Borneo. Some of the African species are asserted, on good authority, to lead the way to bees' nests, their share of the plunder being apparently the grubs in the combs.

Passing over the brilliantly coloured trogons (*Trogonidæ*) of tropical regions and the actively climbing little mouse-birds, or colies (*Coliidæ*), of South Africa, we come to the American family of humming-birds (*Trochilidæ*), which, though mostly found in the tropical parts of the New World, range from Tierra del Fuego to Sitka. Their wonderfully coloured metallic plumage almost defies description, and their wings can be moved up and down so rapidly as to be almost invisible, producing at the same time the humming sound from which the popular name has been derived. Like the African sun-birds, they render service to a number of bright-blossomed plants by transferring pollen.

The swifts (*Cypselidæ*), represented in Britain by one species only (*Cypselus apus*), if rare stragglers are ignored, closely resemble swallows in appearance and habits, but differ from them in many structural features.

The goatsuckers, or nightjars (*Caprimulgidæ*), share with bats the work of hawking for insects after sunset. Some species, however, feed during the day. Our harmless nightjar (*Caprimulgus

europæus), though much maligned, is a most useful bird, which wages war on many insect pests. It is greatly aided in this pursuit by an unusually wide mouth, fringed with bristles. A well-known foreign species is the whip-poor-will (*Antrostomus vociferus*) of America, while the more-pork bird (*Podargus cuvieri*) of Tasmania belongs to a closely related family.

The best-known members of the hoopoe family (*Upupidæ*) are distinguished by the possession of a beautiful crest on the head, well seen in the common species *Upupa epops*, which ranges from Britain (where it is an occasional visitor) to Japan.

The hornbills (*Bucerotidæ*) of Africa, India, and the Australian region are remarkable for their enormous beaks, upon the upper side of which is often a large projection known as a "casque" or helmet.

The bee-eaters (*Meropidæ*) are brilliantly coloured birds, with slender, curved beaks, found in most parts of the Old World. One species (*Merops apiaster*) occasionally wanders to our southern shores. The same bird is well known and dreaded by bee-masters in Spain.

Kingfishers (*Alcedinidæ*) are nearly all natives of the Old World, possessing long, powerful beaks, and, for the most part, brilliant plumage. The third and fourth toes of their comparatively feeble feet are largely united together. This peculiarity probably assists our native species (*Alcedo ispida*) to maintain its hold easily on some branch near a stream while it patiently awaits the fishes upon which it preys.

Cuckoos (*Cuculidæ*) are widely distributed through both hemispheres, but only the Old World species, and not all of those, trade on the parental affection of other birds. The feet resemble those of woodpeckers. Our native cuckoo (*Cuculus canorus*) is not unlike a hawk in appearance, and the familiar love-call, which is uttered by the male bird only, is not a general characteristic of the family.

Order 3. Owls (*Striges*). There is only one family (*Strigidæ*), including familiar nocturnal birds of prey, with soft plumage, large eyes, and hooked beaks. Their general appearance is too well known to need detailed description, but it may be mentioned that the fourth toe can be turned either forwards or backwards at will. The young are helpless. Owls are found all over the world, and the most notable British species is, perhaps, the barn-owl (*Strix flammea*), which even yet awakes superstitious fears.

Order 4. Parrots (*Psittaci*). Here, again, we have but a single family (*Psittacidæ*), with some members of which everyone is acquainted. Climbing feet are present, with well-curved claws, but the most remarkable feature is the prominent hooked beak, the upper part of which is movable, being united by a hinge-joint to the skull. This increases its efficiency for both feeding and climbing purposes. The young are naked and helpless.

Parrots are most strongly represented in the Australian region and South-east Asia, after which comes South America. Africa and South Asia are pretty well off in the number of species, but only one is to be found in North America.

The curious nocturnal kakapo, or ground parrot, of New Zealand (*Stringops*), has almost lost the power of flight, and radiating feathers round the eyes give it an owl-like appearance. The pretty little grass parakeets, or budgerigars (*Melopsittacus*), are natives of Australia, while the name "love-bird" is given to some small African (*Agapornis*) and South American (*Psittacula*) forms. Well known are the African grey parrot (*Psittacus erithacus*), notable for its imitative powers, and the gaudy American macaws. The crested cockatoos (*Cacatuinæ*) are only to be found in the Australian region, and north from this to the Philippine Islands.

Order 5. Pigeons (*Columbæ*). These are plumply built birds, with nostrils situated within a bare patch of swollen skin (*cere*) at the base of the beak, which is well developed, and mostly suited to vegetable food, for the temporary accommodation of which the gullet is swollen into a large crop. Only the first toe is turned back, and the feet are suited both for perching on trees, which are the usual home, and progression on the ground. The young are naked and helpless.

Pigeons and doves (*Columbidæ*) are very widely distributed, and of the four British species the rock-dove (*Columba livia*) is most interesting, as representing the ancestral stock from which all the domesticated breeds of pigeon have arisen by artificial selection. The large crowned pigeon (*Goura coronata*) and allied species, native to New Guinea and the adjacent islands, are perhaps the most striking forms.

Order 6. Gulls and Auks (*Lariformes*). The gulls (*Laridæ*) are very widely distributed sea-birds, of which the staple diet consists of fish and other marine animals, though at times they may migrate inland for feeding purposes, as well as for breeding. The feet are webbed, and the great toe is small. The young are fairly helpless. Our commonest native species are the common gull (*Larus canus*), the herring-gull (*L. argentatus*), and the black-headed gull (*L. ridibundus*). The terns, or sea-swallows, are related forms, with pointed tails and wings, and the common tern (*Sterna fluviatilis*) frequents the British coasts. The chief British representatives of the auks (*Alcidæ*), which resemble gulls in structure and habits, are the razor-bill, the guillemot, and the curious puffin or sea-parrot (*Fratercula arctica*).

Order 7. Plovers (*Limicolæ*). The birds of this order are cosmopolitan, and are distinguished by the slender, often elongated, beak, while many of them are long-legged waders. The feet are not webbed. The young are covered with down when hatched, and soon learn to look after themselves.

Of well-known British species belonging to the chief family (*Charadriidæ*) the following may be mentioned: Golden plover (*Charadrius pluvialis*), ringed plover (*Ægialitis hiaticula*), curlew (*Numenius arquata*), lapwing or peewit (*Vanellus cristatus*), common sandpiper (*Totanus*

hypoleucus), woodcock (*Scolopax rusticola*). and common snipe (*Gallinago cœlestis*).

Order 8. Rails (*Fulicariæ*). These are somewhat primitive forms, in which the laterally flattened body facilitates progress through grass and thick undergrowth. Many of them have lost the power of flight. The young are covered with down when hatched, and able to run about.

The best-known British species included in the single family (*Rallidæ*) is the landrail, or corncrake (*Crex pratensis*), and of aquatic forms we have the water-rail (*Rallus aquaticus*), moorhen (*Gallinula chloropus*), and coot (*Fulica atra*).

Order 9. Bustards and Cranes (*Alectorides*). These are long-legged birds, the young of which are well developed when hatched, as in the last order.

Bustards (*Otididæ*) are Old World forms which mostly live on plains. The great bustard (*Otis tarda*) was once a native of Britain.

The graceful cranes (*Gruidæ*) are widely distributed waders, of which one species, the common crane (*Grus communis*), was a native of East England till the end of the sixteenth century, but is now only a rare visitor.

Order 10. Game Birds (*Gallinæ*). The members of this order are ground-birds, with strong, blunt-clawed feet adapted for scratching up the ground in search of food. Their young are soon able to take care of themselves.

Apart from the mound-builders (*Megapodiidæ*), the curious nesting habits of which will be elsewhere mentioned, the only family requiring notice is that including pheasants and their allies (*Phasianidæ*), some of which are to be found native in most parts of the world. Several familiar domesticated birds belong here—*e.g.*, guinea-fowl, which have been derived from a West African species (*Numida meleagris*); and turkeys, descended from a North American form (*Meleagris gallopavo*). The red jungle-fowl (*Gallus bankiva*) of South Asia is ancestral to domesticated fowls, and the peacock (*Pavo cristatus*) was originally native to the same region.

The following game-birds and ornamental forms also belong to the pheasant family: Argus pheasant (*Argusianus argus*), golden pheasant (*Chrysolophus pictus*), common pheasant (*Phasianus colchicus*), common quail (*Coturnix communis*), partridge (*Perdix cinerea*), capercaillie (*Tetrao urogallus*), black grouse (*Lyrurus tetrix*), red grouse (*Lagopus scoticus*)—the only undoubted species of bird restricted to Britain—and the ptarmigan (*Lagopus mutus*).

Order 11. Eagles and Vultures (*Falconiformes*). The predaceous character of the members of this order is clearly indicated by the strong, hooked beak and the powerful talons. The great toe cannot be turned forwards at will as in owls. The young are helpless, and remain for an exceptionally long time in the nest. Members of this order are to be found all over the world.

As a type of the larger members of the falcon family (*Falconidæ*) the golden eagle (*Aquila chrysaëtus*) may be taken. This handsome bird, or some allied species, served as the emblem of Rome in older times, and contributes largel to the heraldry of modern Europe. It breeds in Scotland (here and there in Ireland also), and has a very wide range in the Northern Hemisphere. A number of smaller species belonging to the family are also British, and of these the kestrel (*Falco tinnunculus*) and sparrow-hawk (*Accipiter nisus*) are familiar. The bare-necked, carrion-feeding vultures are divided into two families, of which one (*Cathartidæ*) includes the American forms, and the other (*Vulturidæ*) the Old World species. The gigantic condor (*Sarcorhampus gryphus*) of the Andes, with its 9-ft. spread of wing, is surpassed in size by no other existing flying bird, while the little Egyptian vulture (*Neophron percnopterus*) is one of the smallest members of the group.

Order 12. Ducks, Geese, and Flamingoes (*Anseres*). The species of this large and cosmopolitan order are web-footed, aquatic birds, mostly possessing a flattened bill. The young are able to run as soon as hatched.

One extensive family (*Anatidæ*) includes ducks, geese, and swans. Our wild duck (*Anas boschas*), ancestral to the domestic form, is a typical representative of the first group. Of diving species the eider-duck (*Somateria mollissima*) is one of our winter visitors, while teal (*Querquedula crecca*) and widgeon (*Mareca penelope*), both non-divers, are common objects of sport.

Of geese indigenous to Britain, the grey lag (*Anser cinereus*) is perhaps the best known, and the domestic form is probably descended from it. Swans are characterised by their long necks and shorter bills. The white swan (*Cygnus olor*) is common throughout Europe, and also ranges into Asia and North Africa. The black swan (*C. atratus*) of Australia and the black-necked swan (*C. nigricollis*) of South America are remarkable on account of their colour.

The long-legged flamingoes (*Phœnicopteridæ*) are transitional to the storks, and possess a large beak, of which the end is sharply bent down, while red is the prevailing colour of their plumage. The common flamingo (*Phœnicopterus roseus*), widely distributed through Europe, Asia, and Africa, is rose-coloured.

Order 13. Herons and Storks (*Herodiones*). The long-legged waders which make up this order are represented in all parts of the world. The beak is long, strong, and pointed, and the feet are never more than partially webbed. The young are helpless.

Herons (*Ardeidæ*) are chiefly represented in Britain by the grey heron (*Ardea cinerea*), to which the bittern (*Botaurus stellaris*), now only an irregular visitor, is allied.

Of storks (*Ciconiidæ*), the common white species (*Ciconia alba*), occasionally seen in the east of England in spring, is sufficiently abundant in Europe, from which it migrates in late summer to Africa. The bald-headed adjutants or marabout storks, with huge beaks, are among the most amusing inhabitants of the Zoological Gardens. They are indigenous to Africa and India, and the bareness of the head is an adaptation to the carrion-feeding habit.

Order 14. Pelicans and Cormorants (*Steganopodes*). This order embraces short-

FEATHERED LIFE FROM MANY COUNTRIES

MARTIAL HAWK-EAGLE

ELATE HORNBILL

SPOTTED EAGLE

EAGLE-OWL

WANDERING ALBATROSS

KING CONDOR

FLAMINGO

GREAT BARBET

SACRED KINGFISHER

BLACK AND WHITE GOOSE

RED-BACKED SHRIKE

VULTURINE GUINEA-FOWL

MARABOUT STORK

DEMOISELLE CRANE

legged aquatic forms, which chiefly feed upon fish. All four toes are connected by webs. The young are helpless.

The pelicans (*Pelecanidæ*) are comical-looking birds with a very large beak, on the under side of which is a large pouch for the temporary reception of food. The common white pelican (*Pelecanus onocrotalus*) is native to South-east Europe and parts of Africa.

Cormorants (*Phalacrocoracidæ*) are among the most industrious fishermen of the sea-coast. We have two native species, the large black cormorant (*Phalacrocorax carbo*) and the small green cormorant or shag (*P. graculus*). The gannets (*Sulidæ*) are represented in Britain by the common gannet or solan goose (*Sula bassana*), of which a noted breeding-place is the Bass Rock in the Firth of Forth.

THE KIWI
From a Photograph by W. P. Dando

Order 15. Petrels and Albatrosses (*Tubinares*). The strong, somewhat hooked beak of the birds included in this order is well adapted for fish-eating, the feet are webbed, but the great toe is reduced or absent. The nostrils are placed at the end of short tubes. Many of the species frequent the open sea. The young are helpless.

There is but one family (*Procellariidæ*), of which the following members may be noticed: The storm petrel (*Procellaria pelagica*), known to sailors by the name of "Mother Carey's chicken," and the wandering albatross (*Diomedea exulans*) with an enormous spread of wing.

Order 16. Divers and Grebes (*Pygopodes*). This is another group of thoroughly aquatic birds, well adapted to the pursuit of fish. The strong, sharp beak is flattened from side to side, the legs are set on very far back, and the feet are much as in the last order, except that in the grebes they are not webbed, but the toes are fringed with flaps of skin. The young are helpless.

THE AUSTRALIAN CASSOWARY

Our commonest native species of the sharp-beaked divers (*Colymbidæ*) are the great northern diver (*Colymbus glacialis*) and the red-throated diver (*C. septentrionalis*). Two of the grebes (*Podicipedidæ*) haunt our inland waters, the great crested grebe (*Podicipes cristatus*) and the little grebe or dabchick (*P. fluviatilis*).

Order 17. Penguins (*Impennes*). These curious inhabitants of the Southern Hemisphere are all placed in one family (*Spheniscidæ*), of which the members are better adapted to an aquatic life than any other birds. The wings are useless for purposes of flight, but are converted into efficient paddles. All the toes are connected by webs except the small first one, and the legs are set on exceedingly far back. The sharp beak is straight, and the young are helpless when hatched out.

RUNNING BIRDS

The running birds, characteristic of the Southern Hemisphere, have lost the power of flight, in accordance with which the breast-bone has no projecting keel. They have specialised for swift progression on the land, and the feathers are loose in texture. The young are able to run about as soon as hatched.

One family (*Struthionidæ*) includes only the African ostrich (*Struthio camelus*), the largest existing bird, being as much as 8ft. high. Only the third and fourth toes are present, the former being much the larger. Both are padded below, like the extremities of camels, and for the same reason.

South American ostriches (*Rheidæ*) are smaller forms, possessing three toes. The same number of digits are present in the cassowaries (*Casuariidæ*) of North Australia, New Guinea and the adjacent islands. The black plumage is hair-like, and the neck is more or less bare, and usually wattled, these parts being brightly coloured. There is a bony outgrowth, or "helmet," on the head.

The three-toed emeus (*Dromæidæ*) are not unlike cassowaries, though somewhat larger, but possess neither the brightly coloured bare patches and outgrowths in the neck region nor the "helmet" of the latter.

The kiwi (*Apteryx*) of New Zealand represents still another family (*Apterygidæ*), and is the only living running bird possessing all four toes. It is about the size of a large fowl, and its long, narrow beak is used in probing the ground for earthworms.

J. R. AINSWORTH-DAVIS

Development of Electric Supply. Steam-turbine and Internal-Combustion Sets. Power-station Design. Utilisation of Water Power.

ELECTRIC POWER STATIONS

Power stations for the supply of electrical energy have a very interesting history. Thirty years ago they were, in fact as well as in name, "central" stations, the controlling factor in the choice of a site being its relative distance from the centre of the area to be supplied. The station consisted of a boiler-house equipped with two or three boilers, generally of the "Lancashire" or "Economic" type, and an engine-room, where open-type non-condensing engines of 200 or 300 h.p. (or less), drove, by ropes or belting, small dynamos generating continuous currents at a pressure of 100 to 120 volts. The coals usually had to be carted to, and the ashes carted away from, the station, the water for the boilers being supplied from the public mains.

London's Electric Power. In 1912 there were, in the County of London alone, 38 generating stations, supplying electric energy for public lighting and power purposes. These represented a capital outlay of over £21,000,000, and they were large enough to deal with a total maximum load of 163,000 kilowatts. Their engines represent a total equipment of about 200,000 h.p., and they produced in the year nearly 300,000,000 units. Adding to this the energy used to supply the various railways and tramways worked electrically in the County of London, the total number of units of electric energy used in 1912 was over 675,000,000 units.

The Development of Supply. It is not possible here to follow in detail all the developments. The use of the three-wire system of mains increased the permissible area of supply of the continuous-current system; and later the almost universal adoption of 200-volt lamps, allowing a pressure of 400 volts across the outer conductors of the mains, gave still another extension. With alternating currents it was usual, in the early days, to lay high-tension 2000-volt mains in the streets, and to fix in consumers' houses the necessary transformers to reduce the pressure. Experience, however, proved that this was very uneconomical, and the practice of constructing sub-stations with transformers large enough to supply the surrounding area became general.

These considerations made it possible for the generating stations of both continuous and alternating current systems to be placed outside the area of supply, and more regard began to be paid to the advantage of placing the power-house near to a railway or to a canal or river, so that fuel and water could be obtained cheaply. Between 1883 and 1886, belt-driven continuous-current sets gave way to Willans' high-speed engines direct-coupled to the generators; and the "Lancashire" or "Economic" boiler to the "Babcock" water-tube type. In alternating current stations the tendency was to adopt slow-speed engines, and to mount the alternator parts on the periphery of the flywheel. The sizes of units increased, and the Belliss and other enclosed types of engines competed with the Willans for general favour; but till the coming of the steam-turbine, about the year 1900, general practice was along these lines.

The Pioneer of Modern Power Schemes. There were, however, in the early days, men who saw that the problem of electric power-supply could never be satisfactorily solved by the erection of large numbers of comparatively small stations, and one of these men, Mr. S. Z. de Ferranti, had the courage to think out the whole problem, and proceed to put his conclusions into practice. Mr. Ferranti was connected with a company which was supplying part of the West-End with electric light by means of alternating currents generated at the Grosvenor Gallery. This company, the London Electric Supply Corporation, Limited, acting on Mr. Ferranti's advice, bought a large riverside site at Deptford, where seaborne coal could be delivered direct into the station, and an unlimited water supply was available for condensing. Mr. Ferranti laid out the station for a final capacity of 120,000 h.p., the first instalment of which were to be two 1500 h.p. steam alternators. These machines were made and put into service, and two larger sets, namely 10,000 h.p. size, were partly constructed. What these would have looked like had they been finished, and how they compared as regards size with modern turbine sets of equal output, is shown in **182**. The energy was generated at 10,000 volts, and transmitted through specially made paper-insulated cables to Charing Cross, some six miles distant.

This bold scheme was not entirely successful, because it was so far in advance of the manufacturing ability of the day, but perseverance won; and, after surmounting many unanticipated difficulties, the station is now a thorough success, and the pioneer of practically all modern power schemes. For some years very few ventured to follow in Mr. Ferranti's steps, and central station progress was rather in the gradual development of the local station.

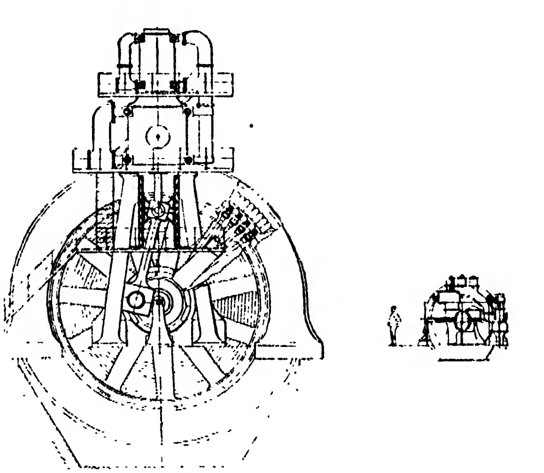
Power Stations. The coming of the steam-turbine, with its possibilities of economical working, led the Newcastle-on-Tyne Electric Supply Company, about the year 1900, to erect the Neptune Bank generating station near Newcastle-on-Tyne, and seriously to begin the business of supplying electrical power at low prices for industrial purposes.

This station was the first of what may be termed British central electric power stations. A plain building of workman-like exterior

housed a number of turbo-alternators which were supplied with steam from a battery of water-tube boilers. The turbines worked with condensers, and every effort was made to keep down the total cost of generating energy. The venture was a great success. So many of the neighbouring engineering and other works decided to purchase power that soon the station was fully loaded, and larger stations at Carville and Dunston have had to be built. The result of this enterprise is that during the last ten years an extensive network of high-tension electric mains has been laid down in the Tyne industrial district, and, at the present time, a great part of the power used is supplied from one or the other of the central electric power stations. The effect on the commercial prosperity of the district has been very marked, the purchasers getting their power at a very low price, which the conditions of supply render profitable to the company.

The example of the Tyne undertaking caused a number of power companies to be formed. Some of these, particularly those operating in the Lancashire, Yorkshire and Clyde districts, have proved successful; others have not yet got over their early struggles to find sufficient customers to make the undertaking pay commercially.

In the chapters on dynamo and alternator design reference has been made to the large generating units which the perfecting of the steam turbine has made possible. How these large sets are sometimes congregated under one roof is shown in **183**, which illustrates the interior of the Lots Road power house, Chelsea, where eight 6000 k.w. turbo-alternators are in daily use, supplying electric energy to most of the London underground railways.



182. 10,000 H.P. STEAM ALTERNATORS OF THE LONDON ELECTRIC SUPPLY CORPORATION IN 1912 AND 1890
The illustrations to th

Station Design. There are many points in power-station design which it is not possible to deal with in detail here. Enough has been said to show the great importance of generating at the lowest possible cost consistent with reliability of supply. This means careful planning of the lay-out of the station to reduce the risk of breakdown to a minimum. Fig. **185** gives a very fair example of modern practice for a medium-sized station. It represents the new power-house at Stoke-on-Trent, where there are two 1500 k.w. turbo-alternators, with provision for a third set. The boilers are as near as possible to the generating units, and the steam pipes are arranged so as to permit any boiler to supply any generator. The plant is too small, however, to allow for a complete subdivision of the boilers.

Perhaps, however, the best idea of up-to-date practice for important stations is shown in **184**, which illustrates the lay-out of one of the large power-houses which has been erected at Rosherville, near Johannesburg, by the Victoria Falls and Transvaal Power Company. In this station five 10,000 k.w. turbo-alternators, six 3500 k.w., and three 7000 k.w. turbo-driven air-compressors are accommodated. The plan shows the modern method of sub-dividing the boiler plant into separate batteries, each of which is independent of the other, and supplies a definite section of the generators. In this way the sets are sub-divided, and a breakdown in any part of the system affects only the particular section to which it belongs. This plan is generally followed in stations, both in this country and the United States, where some very large power-houses have recently been equipped.

Switch Gear. Much might be written about the switch gear necessary for the control in these large stations. The switches themselves are generally placed in separate fireproof chambers, and are operated electromagnetically by means of small currents controlled from a centr l point. Fig. **188** giv s an idea of such a central point from which the switch gear of a large station is controlled and operated. The old system of crowding the switch and control gear into as small a space as possible in the engine-room is now generally abandoned, and the switches, at any rate, and often the whole control gear, are placed in either a separate room or a separate building.

Power Costs. There are two things which have much to do with the cost at which electricity can profitably be sold. One is the *load factor*, and the other the *diversity factor* of the demand.

Suppose a large station with its network of cables is ready to supply, say, 5000 k.w. at any moment. Its cost of production may be divided into two parts: (1) The total interest and sinking fund charges on the capital cost of the undertaking, which are a fixed sum whatever the output of the station; and (2) the actual cost of working, which includes the outlay on fuel, water, oil, and other materials, the wages of the men, salaries of the staff, and similar charges. These are variable, and depend upon the output; that is, on the number of units of power sold.

The Load Factor. If the capital outlay of the above undertaking be taken at £250,000, interest and other capital charges at 6 per cent. would mean that a sum of £15,000 per annum would have to be found for these charges, whatever the output. If the whole of the running plant were supplying electric energy day and night throughout the whole year, the number of units sold would be 5000 k.w. × 8760 hours per annum = 43,800,000 units. This output, if obtained, would imply a load factor of 100 per cent., because the whole running plant would be working at full load all the time. If the output were half this amount, or 21,900,000 units, the load-factor would be 50 per cent., because the output is equal to the whole running plant working at full load 50 per cent. of the time.

183. INTERIOR OF LOTS ROAD POWER-HOUSE, LONDON, WHERE EIGHT 6000 K.W. TURBO-GENERATORS ARE IN DAILY USE. (From a photograph by Messrs. C. A. Parsons & Co.)

The *load factor* means the ratio, expressed as a percentage, of the actual output to the possible output if the whole of the running plant had

Percentage. Load Factor.	No of Units sold per annum.	Cost of Production per Unit.	Cost of Production.	Capital Charges.	Total Cost.	Total Cost per Unit.
		Pence.	£	£	£	Pence.
1%	438,000	1·50	2,737	15,000	17,737	9·72
10%	4,380,000	0·90	16,420	15,000	31,420	1·72
20%	8,760,000	0·60	21,900	15,000	36,900	1·01
40%	17,520,000	0·40	29,200	15,000	44,200	0·61
80%	35,040,000	0·30	43,800	15,000	58,800	0·40
100%	43,800,000	0·25	45,630	15,000	60,630	0·33

been working at full load every hour of the year. What influence the load factor has upon the total cost per unit is shown in the table above.

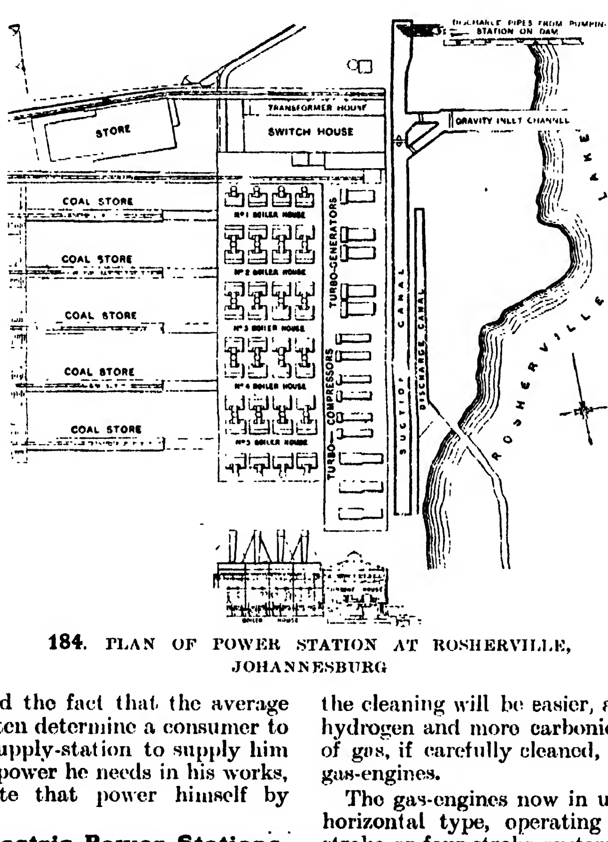
The figures taken as the cost of production are near those which would probably be realised in practice. They include rates, salaries, and office expenses, as well as fuel, water, oil, and wages. The last column shows what a very important item load factor is in determining the total cost of producing energy, and in the justification for the low prices which are often charged to long-hour power consumers. For instance, a price often quoted to such a consumer would be, say, £4 per annum per k.w. of maximum demand, plus ½d. per unit.

The Diversity Factor. The second important consideration is termed the *diversity factor*. This factor really determines the number of consumers which an undertaking may safely connect to its mains. It is found by observation for each district. In the above instance, when the running load—excluding spaces—at the station is 5000 k.w., motors or lamps might be connected to the main till the total nominal load reached 5000 k.w. If, now, the actual load at various times of the day were ascertained, it would probably be found that, owing to all the motors not being in use at full load, and all lamps not being alight at the same time, the maximum output would not exceed, say, 3000 k.w. The diversity factor would be the ratio of the total connected load to the maximum demand on the station; that is, 5000 ÷ 3000 = 1·66. This means that the station could safely connect to the mains a nominal load of 5000 × 1·66 = 8300 k.w., in motors or lamps, without being obliged to increase the plant in the station. This fact enables the capital charges to be better

allocated than in the rough way shown above. It is the use which the central-station manager makes of his knowledge of the character of the supply that enables him to frame tariffs which are at the same time attractive to the consumer and profitable to his undertaking.

Separate Supply. Electric power supplied from public supply mains finds as one of its principal rivals the independent generating plants which are sometimes installed in individual works. These plants may be driven by steam, gas, or oil power. It would be interesting to examine carefully the claims of these varied methods of generating electric power, and to compare them to the large power station. It must suffice to say that this problem largely resolves itself into questions of capital outlay and load factor.

Now, internal combustion engines using gas or oil have much higher thermal efficiencies than steam-engines, and from the point of view of getting the maximum amount of electrical energy from a given weight of fuel they are much superior to steam-engines, especially if the distribution losses of public supply be taken into account. In very many cases, however, the greater convenience of the purchased energy, the absence of need for laying out capital on private generating plant, and the fact that the average cost remains low, often determine a consumer to contract with the supply-station to supply him electrically with the power he needs in his works, and not to generate that power himself by engines of his own.



184. PLAN OF POWER STATION AT ROSHERVILLE, JOHANNESBURG

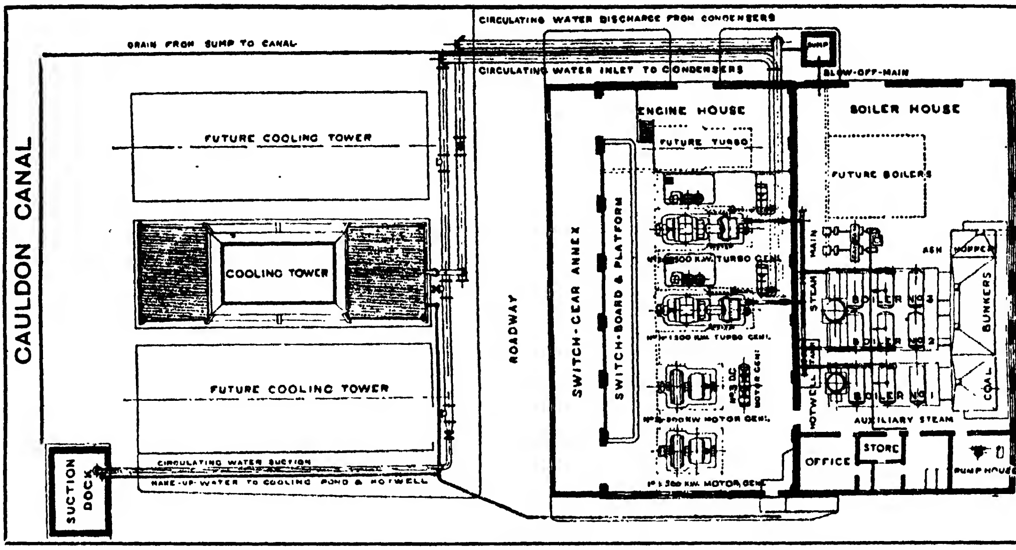
Gas-Driven Electric Power Stations. The internal combustion engine has undoubtedly a future in regard to the central-station work. Had it not been for early failures, and the advent of the steam-turbine, it would no doubt have come into more extended use before this. In small stations the Diesel oil-engine, with its power of using cheap fuel and its high thermal efficiency, has been adopted in a number of cases with marked success, the absence of stand-by losses helping to reduce the station working cost. Such engines are, however, very costly, and they are not available in very large sizes.

The gas-engine has a fine field when it can be installed near blast furnaces, or, indeed, in any place where it is possible to get hydro-carbon gas at a low price. This is the case in Westphalia, where many large gas-engines are working with blast-furnace gas; and in Durham, where several large gas-engine power-stations have been erected to utilise the waste heat from various industrial processes. The most general way of utilising gas-power is, however, to convert the fuel into producer-gas, and to pass this direct into the cylinder of the gas-engine. The process is more direct than using steam as the intermediary between the fuel and the engine, and the heat losses are much less. A very complete producer and gas-engine plant has been installed at the Runcorn works of the Castner-Kellner Company, who use over 20,000,000 units every year for electro-chemical purposes.

The Gas-Engine at Work. In gas-producer plants the fuel is heated, and a known quantity of either air, or air and steam, is passed through the incandescent mass. If the coal is soft and bituminous, the resultant gases contain a high percentage of tarry matter, which must be removed from the gas before it reaches the engine. Such a gas will be rich in hydrogen. If the coal is hard, resembling anthracite, there will be less tar in the gas, the cleaning will be easier, and there will be less hydrogen and more carbonic oxide. Both sorts of gas, if carefully cleaned, are very suitable for gas-engines.

The gas-engines now in use are largely of the horizontal type, operating on either the two-stroke or four-stroke system. These engines are now made in sizes up to 3000 h.p. As they run at slow speeds, they are bulky and occupy considerable space. The high efficiency of a gas plant working at or near full load is a great factor in its favour; and it is probable that several steam stations may instal gas plants in the near future. If they do, it will be with the object of reducing their cost by working the gas plant at or near full load to carry the steady part of the daily load, and to use steam plant for the peak loads.

In cases of the installation of large producer gas plants using bituminous coal, it is possible by adopting the Mond system to obtain from the

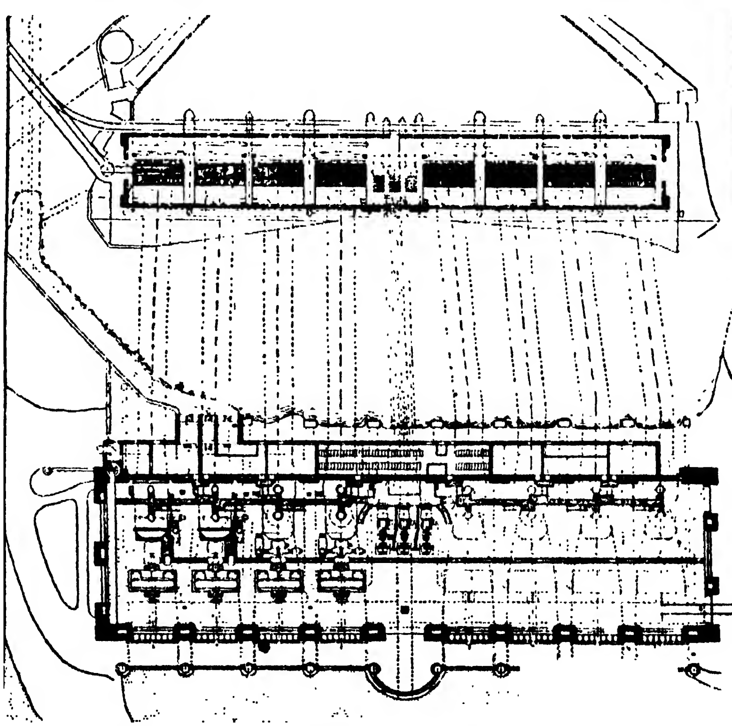


185. PLAN SHOWING THE GENERAL LAY-OUT OF THE POWER STATION AT STOKE-ON-TRENT

gas, before use, such a quantity of ammonia sulphate as will pay all the fuel costs. It will therefore be seen that, although there are comparatively few gas-stations at present working, there are reasons why they may in certain cases come into more general use.

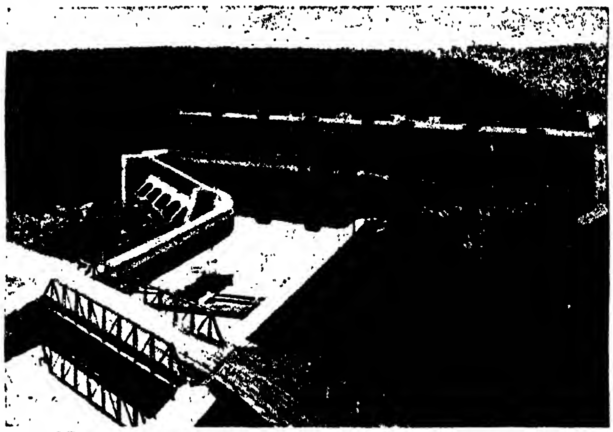
Water Power Stations. Another type of electric power station makes use of the energy derived from falling water. In this country suitable water powers for electric power stations are very few, and, so far as public electric light stations of any size are concerned, Worcester and Chester are practically our only examples, and in both cases the actual fall is very small.

In Scotland, at the Fall of Foyers, and at Kinlochleven, electric power houses of considerable output exist, the energy being used for such industrial purposes as the manufacture of aluminium and calcium carbide. In other countries vast amounts of water power—or "white coal," as it is termed in France—are utilised for industrial purposes, the power being electrically transmitted often over long distances. The United States, Canada, Norway, Sweden, Switzerland, and Italy are a few of the countries in which water-power has been developed. It does not follow, because the water power itself costs little or nothing, that the electric power produced is necessarily cheap. This depends upon the character and cost of the civil engineering works—such as masonry dams, forebays, intake canals, and tailraces—necessary to utilise the power. In many cases the cost of these works is enormous, and the interest charges alone may form an important factor in the cost of the supply.



186. PLAN OF POWER STATION AND FOREBAY, TROLLHÄTTAN

Power from Waterfalls. The power available from any waterfall depends upon two factors: (1) The quantity of water flowing per minute; and (2) the height of the fall. Water powers are roughly divided into high-pressure falls, where the quantity of water may be small but the height of the fall is considerable; and low-pressure falls where the quantity is large and the height of the fall low. Different types of water turbines are used in the two cases, and efficiencies of 75 per cent. to 80 per cent. are frequently obtained with either class.

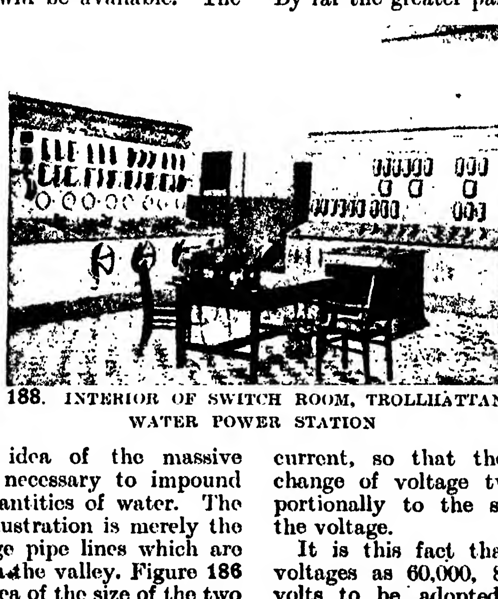


187. POWER CANAL AND FOREBAY, TROLLHÄTTAN

An important factor in water-power work is to secure a large reserve of water above the intake; hence it is frequently necessary to build large dams to impound a sufficient quantity to ensure that the water supply shall remain constant through the year.

Many examples could be adduced of water-power stations, but a typical case is the large power-house recently erected by the Swedish Government at Trollhättan, where at present a supply of 80,000 h.p. is available, and where eventually 200,000 h.p. will be available. The River Göta here brings the discharge from Lake Wener, the largest lake in Sweden, which has an area of over 2000 square miles. The power-house is situated at the Falls of Trollhättan, where a fall of 104 feet is available. The present minimum amount of water is over 4,000,000 gallons per minute. The water is carried in a canal to a large forebay, as shown in 187, which is typical of water-power civil engineering work. The illustration gives some idea of the massive character of the works necessary to impound and guide such large quantities of water. The building shown in the illustration is merely the intake for the eight large pipe lines which are led to the power-house in the valley. Figure 186 gives in plan a relative idea of the size of the two buildings, and shows the pipe lines from the forebay to the power-house. These lines consist of steel tubes, about 14 feet in diameter and 137 feet long, led through tunnels blasted out of the solid rock. Three smaller pipes, laid in one tunnel in the centre, feed the exciter turbines. Each pipe line feeds one turbine, which consists of two wheels, enclosed in a common steel case fitted with automatic regulating apparatus. Each turbine runs at 187·5 revolutions per minute, and is directly coupled to a three-phase alternator capable of developing 11,000 K. V. A. at 10,000 volts 25 cycles per second. The size of the alternators needed for such outputs at the low speed may be gauged from the fact that the entire machine weighs 200 tons, and the rotor alone 67 tons.

A separate switch-house, which is illustrated in 188, has been provided for this installation. It shows what expense is necessary in providing for even this one section of the work of transmission and distribution. The actual control is carried out from the generator-room, the main switch-gear being operated by means of magnetic relays. That part of the supply which is used locally is transmitted to the various distributing centres at the generator voltage of 10,000 volts. By far the greater part, however, is transmitted to distant points; and, in order to reduce the transmission losses, it is transformed up to 50,000 volts. The necessary transformers for this purpose are placed in the switch-house.



188. INTERIOR OF SWITCH ROOM, TROLLHÄTTAN WATER POWER STATION

It should be remembered that in thus raising the voltage to five times its original amount the current required for a given power is reduced in the same proportion—namely, to one fifth. The energy losses in the line depend upon the square of the current, so that they are reduced by the change of voltage twenty-five times, or proportionally to the square of the increase in the voltage.

It is this fact that has caused such high voltages as 60,000, 80,000, and even 100,000 volts to be adopted in some of the very long distance transmission schemes which have been carried out in the United States and elsewhere with considerable success.

SILVANUS P. THOMPSON

The Seven Positions. Half Positions. Higher Notes. "Portamento." Extensions. Four-string Chords. Double Stopping.

THE POSITIONS

Hitherto the hand has been in the normal position, the top C having been played by stretching up the little finger. The hand is said to be in the *First Position* throughout the compass of two octaves up to top B, when so situated that the first finger gives the nearest note above that of any open string. But, above the top C, obtained by an extra stretch of the fourth finger, the left hand of the violinist can stop ten extra notes on each string, those of the two upper strings being of the better quality. The method of fingering this considerable range of additional notes should therefore be thoroughly understood.

Shift the left hand towards the bridge a note higher than it has been when playing in the normal position. Be careful to keep the wrist well down, and to let the fingers fall perpendicularly on the strings. The hand is now in the *Second Position*, and the third finger no longer represents C on the fourth string, the second finger having become identified with that note. Amongst amateur fiddlers it is a custom to go from the first to the third position without taking the trouble to learn the second. This is a slack habit. The second position is as easy and beautiful as the third, and the student who devotes attention to the former will later on reap his reward.

It will be observed now that the open strings are no longer utilised. The sooner the student gets accustomed to fingering every note the better. On account of the different quality of the open notes, good players use them sparingly, and only when the tones they produce are otherwise unobtainable. We give in Ex. 13 the fingering of the four strings in the second position.

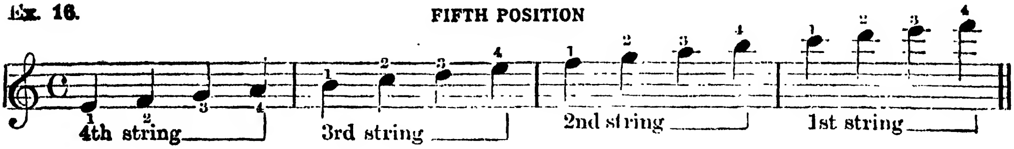
When the hand is shifted up a note still further, it is in the *Third Position*. In this the ball of the left hand rests against the shoulder of the violin, the thumb acting as a brake, so that the hand does not go too far. On approaching the bridge, the student will perceive that the notes lie nearer each other. In consequence, the fingers, especially when stopping

Ex. 13. SECOND POSITION

Ex. 14. THIRD POSITION

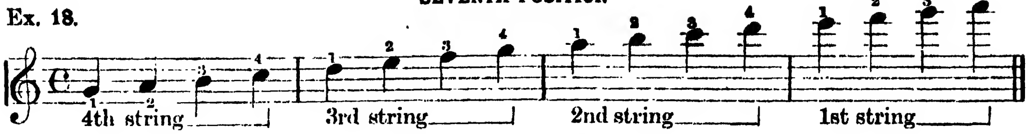
Ex. 15. FOURTH POSITION

Ex. 16. FIFTH POSITION

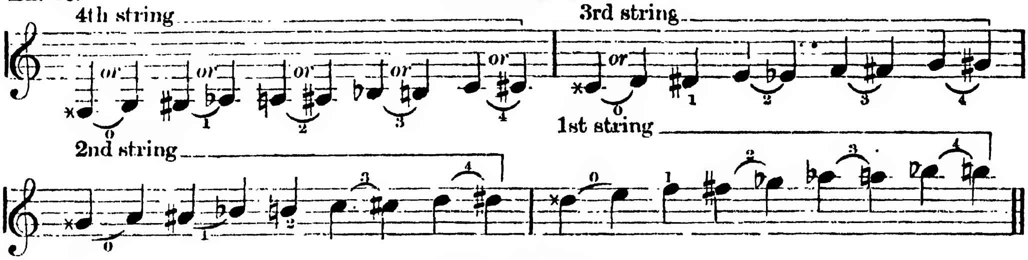


Ex. 17. SIXTH POSITION

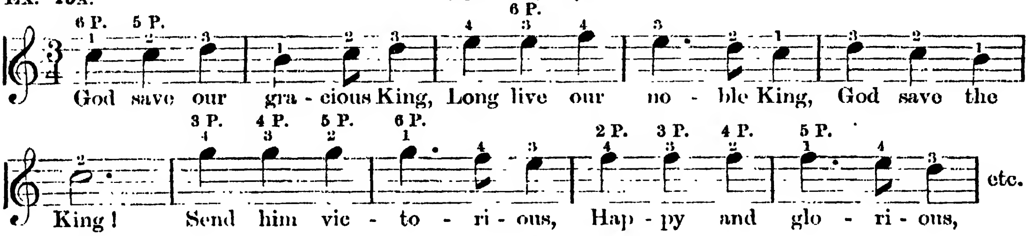
Ex. 18. **SEVENTH POSITION**



Ex. 19. **THE MEZZA MANICA**



Ex. 19A. **FINGER CHANGES**



Ex. 20. **PORTAMENTO**

semitones, come closer together. Should the player's fingers be thick at the tip, he may therefore, before stopping a half-tone, find it necessary to remove the finger which gave the preceding note. Here, then, the C on the fourth string is stopped by the first finger instead of the second, as in the previous position. [Ex. 14.]

Playing the same scale in the *Fourth Position*, and beginning on the note D, this will be stopped by the first instead of the second finger, as before. [Ex. 15.]

In fingering the four strings correctly, the left hand must now be more elevated over the edge of the belly and the elbow carried further under the violin, so that the fingers may be able to reach the G string easily. Hold the instrument firmly with the chin. According to the size of the player's hand, so does the thumb leave the neck of the fiddle and cling to the rim of the belly close to the fingerboard, and in returning to a lower position the thumb always leads the way.

By slipping the hand up so that the first finger takes the place lately occupied by the second, the fingering changes to that of the *Fifth Position*. [Ex. 16.]

In the *Sixth Position*, instead of the index finger representing the first E on the fourth string, the hand moves up and the first finger presses down F. [Ex. 17.]

The top note on the first string is now G (fourth ledger line above staff). This is the limit within which second violin parts in orchestral music are written.

The highest recognised position in violin playing is the *Seventh*, the top note of which is A, and the three semitones above—namely, A♯, B and C—indicate the limit at which stopped notes may be played on the fingerboard. In this position, then, the first finger gives G on the fourth string, exactly an octave above the pitch of the open note. [Ex. 18.]

High Notes. Save that the higher the hand goes up the closer the intervals become, there should be, with practice, little more difficulty in fingering the seventh than the second position. The reason that the higher shifts are generally regarded as presenting great difficulty is chiefly owing to want of familiarity with them, most violin music being written in the lower register. But the mere fact of the intervals being close together in the high positions, and a high note, if played out of

Ex. 21.

tune, being more noticeable than a low one, should stimulate the student to distribute his technical exercises at least equally over the seven positions. For the violinist to confine his attention to the first and third positions puts him on a level with the piano strummer, who is familiar only with the three centre octaves of the keyboard, and neglects all the other notes.

It is not so much the difficulty in fingering as the trouble of reading many ledger lines that causes the student to hold aloof from trying to master the top shifts. It is only by practice that great violinists have learnt to read with equal facility notes high up above the staff as those on it. Considering that the violoncello player must make himself conversant with the bass and tenor clefs as well as the treble staff, the task of the violinist is, comparatively, far less difficult. All that has to be done is for the pupil to proceed systematically in his daily practice, and gradually he will find himself becoming as familiar with the top of the compass as the bottom.

tion, unless he realises that great players have found it enhances the tone of certain melodies, which, like those in the key of B major, lie naturally within the half position. Like many other perplexities in violin playing, it is not so impracticable as it appears to be. The only difficulty to overcome is to place the second finger correctly. [Ex. **19**.]

Whereas, in the second position, the low B is stopped by the first finger, and in the first position by the second finger, the hand being shifted nearer the nut, the same B is negotiated by the third finger. So the second finger takes the A two semitones above the open note of the G on the fourth string, the E two semitones above the open D of the third string, the B on the A string, and the G♭ or F♯ two semitones above the open E of the first string.

Interchanging Positions. Having learnt to play in each position as well as the half shift without moving the hand from its respective situation, the student should study to

Ex. 22.

Ex. 23.

Half Position. In addition to the seven positions described, there is what the Italians call the "Mezza Manica," literally the "half neck," or shift. This is not midway between the first and second positions, as might be surmised. That would make it a position and a half. Instead, the fingers stop the notes one degree *lower* than the first position. The hand must therefore be kept quite close to the nut of the fingerboard. Let the first finger touch the E string peg. In music intended for the half position, a low F× is not infrequently written. The student observing it for the first time may think that it is below the compass of the violin, and that he will have to let down his fourth string slightly to play it.

He may save himself the trouble. If he adds mentally two semitones to F♮, he will understand that the sound required is only the open G. After familiarising himself with the fingering of the seven positions, the self-instructor may regard the half position as an unnecessary complica-

apply the knowledge he has acquired by transferring his fingers from one position to another, so that, no matter on what part of the fingerboard a scale or passage may lie, he may be able to execute the whole of a phrase in the most telling manner, with the least possible temporary hand movement [Ex. 19A]. If in the same group a fresh position has to be taken, and the finger, without leaving the string, glides from one interval to another, the art is so to make the movement as not to develop an ugly whine or wail. The matter of taking the different intervals is termed *portamento*.

Portamento. Even as, in singing, this implies a "lifting" of the voice from one note to another, and the "bearing and behaviour" meanwhile of the artist, so must the left hand of the violinist be taught by practice to move—in more senses than one—in a "correct" way, so that there may be no undue slipping about of the hand on the neck. This is not only ineffective, but undignified. The object in changing

from one position to another is not to whine up and down the strings, but to finger with ease passages which otherwise might be difficult or impossible in the normal position. To enable the portamento to be done effectively, the left hand should be occupied solely in stopping the notes. The instrument, therefore, at such times will be held with extra firmness between the chin and collarbone. [Ex. 20.]

Extensions. In accordance with the way the fingers are stretched to stop the notes, so is the extension known as "superior" or "inferior." The tendency is to play hopelessly wrong notes when first essaying various changes of position. This should be carefully checked by the student transposing a high passage an octave lower. After playing it in the first position, so as to get the sounds well into his head, he can then try it in the higher shifts, together with the portamento effect desired. By continuing to use a uniform style of bowing, linking together with one stroke those notes which are slurred, the student will be able to concentrate his attention on the correct fingering. Whilst he plays as smoothly as possible, his first aim will be to get true intonation, so that whenever an E, A, D, or G occurs, he should test it by the octave of an open string.

"Sopra la 4ta." A knowledge of the higher positions having been gained, extensive skips from low to high notes, and *vice versa*, will become easy if carefully practised, the student always avoiding that whining effect which too much gliding gives. On account of the special character of tone which the lowest string possesses, several bars will sometimes be found marked "sopra la 4ta," which, in English, reads "upon the fourth" string. In that case, the whole of the passage, no matter how high it goes, must be played on the G, and the knowledge the student has of the higher positions will enable him to do justice to the intentions of the composer.

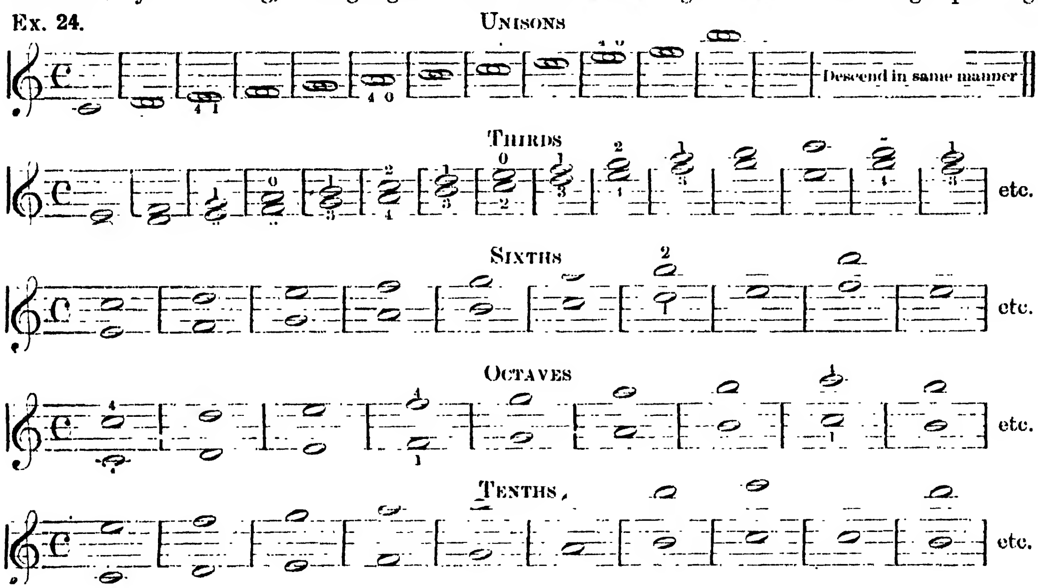
Four-string Chords. So far, we have confined our attention to the fingering of single notes. Agreeably with the human voice, but unlike the piano or organ, the violin is an instrument naturally adapted for monodic performance. Yet it excels the voice in that it can produce several sounds simultaneously from its four strings, certain of the notes being further apart than could be stretched with one hand by any pianist. Four-string chords are usually only possible with short notes. Whisk the hair quickly from the two lower to the two upper strings. Although the bow leaves the two lower strings, the vibrations of the latter continue, and so form the chord. Try Exercise 21 by drawing the bow with a semicircular motion firmly at the nut across all the four strings.

Double Stopping. When two strings are bowed together with either finger pressing them, the effect is known as double stopping. This term also includes the playing of three or four notes at the same time. If a descending passage is begun on the E and A strings, the upper part cannot continue lower than the open sound of the D string, since two notes cannot be emitted from the single G string. Nevertheless, thoughtless composers have been known to write such an impossibility. Now take the double stopping systematically. [Ex. 22.]

After combining the open string simultaneously with groups of four notes, try Exercise 23.

Get well under control ascending and descending unisons, thirds, sixths, octaves, and tenths. [Ex. 24.]

Ex. 24.



By changing the order and duration of these double notes, an inexhaustible series of studies can be made. The life of no violinist has yet sufficed for him to learn everything that can be acquired from this marvellous instrument.

ALGERNON ROSE

The Sorting, Scouring, Drying, Combing, and Carding of Wool. The Bradford Conditioning House. Tests for Oil in Tops.

WOOL-COMBING

The methods used in wool manufacturing are less uniform than those of the cotton trade, because the physical differences between different kinds of wool are more marked than those between different cottons. The industry is accordingly less standardised, and its products are proportionately more various.

It has two main branches, the *worsted* trade and the *woollen* trade, and the essential difference between them is one of aim. The worsted spinner aims at the production of a yarn in which the fibres lie parallel, and the woollen spinner seeks to produce a thread in which the fibres are anything but parallel. They employ for their purposes generally different classes of wool, the worsted spinner using the long or *combing* qualities, and the woollen spinner the short or *clothing* qualities. They employ different machines, but the distinction between them is rather in aim than in material or machinery.

Sorting Wool. It will be convenient to consider the two branches separately, and to begin with worsted, the more important of the two. We have seen (page 637) that wool is bought largely by *topmakers* who, after sorting wool into its separate qualities, proceed to have it combed. Wool-combing is done by some spinners, but it is carried on chiefly as a separate trade by firms known as commission combers working at a fixed charge per pound of *top*. The premises in which combing is done are called sheds, and are commonly of saw-toothed roof construction. Large warehouses are attached to them for the storage of raw wool, and the more modern have accommodation for the opening and sorting of wools.

Sorting is done by a staff supplied by the topmaker, and it may be either a thorough or a perfunctory process. Much depends on the state in which the wool is received. Wool that has been carefully classed and skirted by the seller requires less attention than wools packed with all their dirt, foreign matter, and inferior portions still upon them. The quality of wool varies somewhat from fleece to fleece, and there may be as many as six or eight recognisably different qualities of wool in one and the same fleece. It does not follow that these minuter differences are regarded. But sometimes the fleece is broken into two qualities simply, or the whole fleece may be passed bodily into the blend. Sorting is done at tables usually arranged before the windows, around a well-lit room, and the cleaner wools are handled on what are virtually solid-topped counters. The more dirty varieties are treated upon a wire screen, through which loose dirt can fall out of the way. Screens used for wools that are liable to carry the germs of anthrax are connected with a dust trunk, along which the loose dust is sucked by the action of a powerful fan.

The sorted wool is thrown upon the floor, and bundled through trapdoors to fall into bins below, from which it can be passed to the washing machine. Before being washed the different lots of wool used in making a given quality of top are interblended. Wools from different sources are often put together, and *skin* wools, recovered from the skins of slaughtered sheep, are mingled beforehand with greasy wools, in order that the former may take up some of the yolk or fat from the latter.

Wool Scouring. The dry treatment that suffices for cleaning cotton is insufficient for wool, which carries between 25 and 75 per cent. of impurity. Apart from sand, dirt, and vegetable matter, the impurity consists chiefly of natural oil—the wool fat which when refined yields lanolin, the base of numerous ointments and salves - and potash salts. It is possible, but not always profitable, to recover these potash salts by steeping the wool in fair water before proceeding with washing, and evaporating the water when a high degree of concentration has been reached. This process, known as *desuinting*, is practised somewhat extensively in Belgium and some other countries.

The regular English practice is to pass the sorted and blended wool forthwith into the washing machine [1]. The wool is carried into the first *bowl* or compartment upon a travelling lattice, and thus into a trough from 24 to 30 feet long containing some 1500 gallons of water in which are dissolved from 120 to 130 lb. of soft soap, and 35 lb. of carbonate of potash. The water is maintained at about 120° F., and the trough is fitted with mechanism for moving the wool forward. The object is to wash the material without disturbing it unduly, and this is achieved by the use of swing forks, worked either as a body or individually. The forks have a gentle motion, and they trail the wool through the sud, the first fork delivering it to the second, and the second to the third, until in two or three minutes the wool is brought to the end of the bowl, and is passed through squeezing rollers, from which it emerges cleaner and nearly dry. The wool passes through four such bowls, each time being squeezed dry before entering the next. The succeeding bowls are shorter than the first, and the soap solution in each is progressively weaker, so that in the final bowl the wool gets little more than a rinsing. The dirt removed in each washing is left behind, and the liquors from the machine are treated for the recovery of their grease; and this fat is in some circumstances the source of considerable auxiliary profit.

The Advantage of Soft Water. Not all waters are suitable for the washing of wool, the least so being those containing lime. Soft water is necessary, and the abundance of soft water obtainable in the Bradford district goes to explain the concentration of the wool scouring and combing businesses upon that centre, where practically all the woolcombing in England is done. Hard waters are wasteful of soap, and also detrimental to the softness of the material. The quality of the soap is important, and soap containing free alkali is to be avoided because caustic alkalies make the wool feel harsh and rob it of its strength, so that the fibres break in course of the subsequent treatment.

Scouring Wool with Petrol. Scouring in soap and water is the normal method of washing wool, but there is a spirit-solvent process that is worked on a small scale in this country and on a larger one in the United States. The wool is deprived of its grease by the action of such a spirit as petrol. The work is done in enclosed machines, to guard against the evaporation of the spirit and the risk of fire. The spirit is filtered and used continuously and the mud is removed at intervals. The objection has been raised against this method that it is too thoroughgoing, and succeeds in dissolving out not only the outer grease of the wool fibre but also some other grease that is valuable in preserving the softness of the material.

Wool-Drying. In washing the short *merino* wools somewhat different machines are used from those employed for *crossbred* and *English* qualities, although in the main the machines are alike. The further procedure is also different, depending on whether merino or crossbred is being worked. The crossbred wools are passed through a drying machine after washing, the machines chiefly used being of the enclosed type, into which the wool is fed continuously and carried forward from tier to tier of the machine under a blast of heated air, travelling either with or against the material.

Wool is susceptible of damage and discoloration from heat, and these travelling machines are used to avoid the overheating and unequal drying that sometimes occur in drying wool upon stationary tables. Merino wools are sufficiently dried by being blown along an air trunk to the next machine, or by travelling to it along a creeping lattice situated over a steam pipe.

Preparation for the Comb. The scoured wool is made ready for the comb by one of two processes. The longest wools, measuring six to eight inches in length, are *prepared*, and the others are *carded* upon a machine which has some resemblances to and certain differences from the carding engines used for cotton and those employed in the woollen trade. The object in either preparing or carding is to detach the fibres one from another and to lay them parallel. As the process most usually followed, that of carding is described first.

The Worsted Carding Process. The worsted carding engine is a machine furnished with two or three large cylinders of 50-inch diameter, known as *swifts* and covered with card clothing, on the circumferences of which revolve smaller cylinders, the *workers*, *strippers*, *fancies*, and *doffers*, which also are covered with card teeth of differing fineness, ground at different angles [2]. Merino wools are fed mechanically into the card by the spikes of an ascending lattice apron, but the crossbred wools are fed by hand. The wool is caught first by the clothed rollers, called the *lickers-in*, and it is opened out by opposing rollers, called *dividers*, by which it is carried to the swifts which revolve quickly, carrying round the wool on the points of their teeth. The worker, running more slowly and in the contrary direction, clears the wool from the swift, and it is in turn cleared by the stripper. The fancy rollers are adjusted to raise any remaining wool up to the teeth upon the swift, from which it is removed by the next rollers, the doffers. The effect of the operation is to extend the fibres fairly parallel and to produce a continuous film of wool, as wide as the cylinders. This is removed from the last doffer by a comb and conducted down a funnel and between small rollers whereby the fibre is condensed into a sliver. The rollers are differently clothed for treating different kinds of wool, and, in addition to smoothing out the fibres, they remove sand and vegetable matter remaining behind after washing.

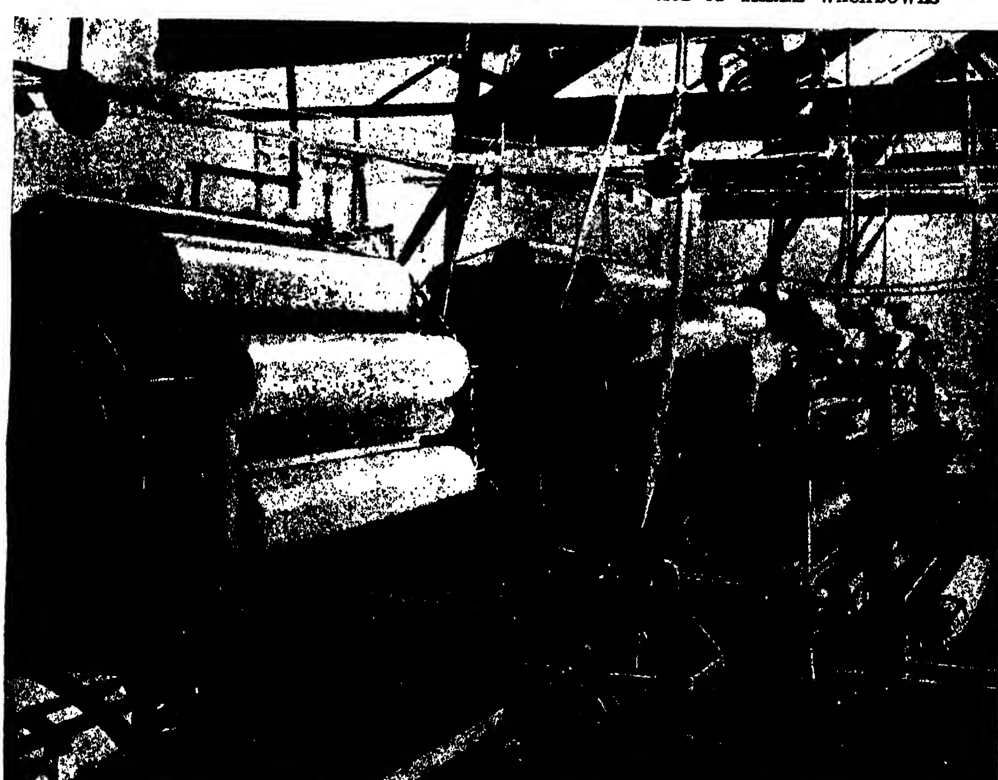
Wool, as we have remarked, carries a good deal of vegetable matter accumulated upon the pastures, the most noxious plant nuisance being the burr-weed, which breaks up into innumerable spiny and tenacious strips. Carding machines are usually fitted with burr-rollers in front of the second swift, and in one effective arrangement the wool is passed beneath fluted rollers under such compression that the burrs are crushed to a powdery state. The wool passes to a roller covered with the finest wire teeth, and is beaten by revolving blades to remove the burr and dust from the material and pass it forward in relatively a clean state.

Backwashing. In carding, the wool loses some of its whiteness, and as colour is taken into consideration by buyers of tops, it is *backwashed.* The backwashing machine has two troughs or bowls, each fitted with squeezing rollers and containing soapsuds and a little laundry blue to correct yellowness of tinge. The sliver passes from the second bowl into a drying chamber fitted either with steam-heated cylinders, or with arrangements for drying the wool quickly in a current of hot air created by blowers or fans. As wool is more freely pliable hot than cold, the temperature of rooms in which carding and combing are done is kept at 70° F., or higher.

Oiling Before Combing. The effect of double washing is to remove the natural oil from the wool, and in replacement of this and to promote easy working in combing, oil is added, usually in a proportion of 3 per cent. The oil, which should be the best olive, or of some readily saponifiable quality, is sprayed, dropped, or applied by roller as the sliver passes into the *backwash gill box*, a machine closely resembling the gill boxes used in following the *preparing* process.

The "Preparing" Process. We have seen that preparing is the alternative to carding, and tops are spoken of as *prepared* or *carded* quality, according as they have been made in the one way as the other. Preparing consists in passing the wool through a machine having, in its simplest form, two pairs of rollers. The front or delivery rollers rotate faster than the back or feed rollers, and consequently *draft* the sliver, or, in other words, draw the sliver out finer. The material is fed into the box by a man known as the *maker-up*, who straightens a little by hand the rather matted mass of wool received from the drying machine. Upon its passage through the back rollers the wool is engaged by steel pins set upright in bars or *fallers.* These fallers are moved continuously forward by the action of a screw, and at the end

1. WOOL DELIVERED PURIFIED AND CLEAN FROM THE LAST OF THREE WASHBOWLS



2. THE CARDING MACHINE TEASING AND STRAIGHTENING THE FIBRES OF THE WOOL

of their traverse, in front of the front rollers, they justify their name by falling to a lower level. They fall upon another screw working in the contrary direction, and are thus carried back to the starting-point, to be raised there to the level of the rollers by the action of a cam.

Drafting. The teeth of the fallers operate to straighten the fibres and to form a continuous length of wool. The wool is led through a succession of these boxes, containing fallers of increasing fineness and with rollers geared at such speeds as will give the desired total degree of draft. The drafting is done gradually, and first in one direction and then in the other, the sliver being reversed on its entry to each successive box, so that the fibres are never pulled twice successively in the same direction. The lap made in the first box is put up at the back of the second and thus into the third, and in passing from this the lap goes down a funnel and through a pair of small rollers, so that it is formed into a sliver and coiled inside a can some 36 inches deep. The slivers from about half a dozen of these cans are led into a fourth box, and are thus drawn into one. The doubling and re-doubling of the slivers is continued at the fifth and sixth boxes, so that a uniform and well-mixed result is obtained.

The wools treated in the preparer gill boxes are long ones, and a careful adjustment of the machines is needed if the fibres are not to be broken. When one end of the fibre is nipped between slow rollers and the other is pulled by the quick rollers the wool is very liable to be snapped in two. To avoid breakage, boxes are sometimes used in which there are two sets of screws and fallers, those nearest the back travelling at a lower speed than those in front. The pulling action of the faller-teeth is made gentler by this arrangement, and the difference in speed between the two sets of fallers gives an extra drafting.

The Purpose of Combing. In the last gilling to which either prepared or carded wool is subjected before being combed, the sliver is wound into the form of balls in readiness for the combing machine. Although the teeth of the fallers or of the card cylinders straighten out the wool, they do not remove the short fibre from the long, which is the principal aim in all combing. The fibres in a good worsted thread are parallel to one another, and are approximately equal in length, and the combing machines are adjusted to remove the *noil*, or fibre of less than the given standard of length.

The Noble Comb. The Noble, or great circle, comb [3] is the type of machine most largely employed and the one suitable for the greatest variety of wools. The comb is circular in form and is driven from an overhead belt. Rollers, each carrying balls of sliver, are set round the outer circumference in racks, and the ends of these slivers are led upward through feed boxes and thus to the teeth or pins of the comb. The great circle is a horizontal ring of brass about 43 inches in diameter, carrying from eight to eleven rows of steel pins. Within this circle revolve two smaller circles of 16-inch diameter, furnished with from five to eight rows of pins. The racks and circles all revolve, and the wool is laid over the teeth of the great circle, forming a fringe. Flat brushes working up and down at high speed dab the wool down into the pins of the large and small circles at the point of contact.

The wool is combed by being drawn through the pins of the opposing circle, and some of it is carried by the large and some by the smaller circles. Whereas the long fibres are drawn out in a fringe, the short ones are left within the comb teeth. These long fibres are drawn off continuously by pairs of upright rollers, and the noil left in the teeth of the small circles is continuously removed by fixed knives and brushes and passed below. The top is led upward and is coiled in a cylindrical can. The machine is substantially built upon a strong foundation, and is heated by a steam chest within the frame. In revolving, the fronts of the feed boxes, or conductors, are automatically lifted clear of the teeth of the great circle except at the points at which combing takes place.

The Nip Comb. For lustre wool, mohair and alpaca, which are all very long wools, the *nip*, or Lister, comb is often preferred. The machine has fallers like those of a gill box, except that in this case the fallers are curved, are heated from a steam coil, and fitted with dabbing brushes. The wool is carried forward by them and delivered not into rollers but into a pair of curved nipping jaws. The jaws draw the wool forward in tufts through the faller teeth and transfer it to a traversing comb by which the wool is presented in a fringe to the teeth of a revolving comb circle. In being drawn off from the circle by fluted rollers the wool receives a further combing from the passing teeth.

French Combing. The shortest merino wools, being those of less than four inches or so in length, are treated on the French, or Heilmann, comb, a machine working upon the same principle as the cotton comb [p. 1693]. The wool is combed tuft by tuft on the pins of a vertical combing circle, and the action is completed by those of an intersecting comb, and the combings are deposited upon an apron to be overlapped into a continuous sliver. French combing is practised chiefly in France, and for the purpose of making soft, bulky yarn from very short-fibred wool. The wool is combed without oil, and the *dry-combing* assists dyers to obtain delicate and accurate shades.

Before leaving the comber's hand the combed wool is passed through *finisher boxes* to intermix the fibres more fully and furnish a sliver of a uniform weight per yard. Normally two boxes are used, and they are like the preparing boxes, already described, except that they are furnished with closer and finer pins. When the tops have been balled they are ready for the spinner, and they then form a readily marketable form of wool in which large transactions take place.

The Conditioning of Tops. In entering the last of the finishing boxes the dry top passes over a brass roller revolving at a regular speed in a water trough, and this roller conducts water to the wool in replacement of that which has been driven off in the drying processes. The quantity applied is regulated by the speed of the roller and the rate of travel of the wool. Dry wool readily absorbs water, and to ensure that moisture is not present in excess the tops are generally sent to the Conditioning House, a testing establishment maintained in Bradford by the municipality.

The tops are sent out by the comber in balls, and at the Conditioning House three of these balls are drawn indiscriminately from each bag. One-third of a pound is drawn from the centre of the first ball, one-third of a pound from the middle ring of the second ball, and one-third from the outside of the third. The one-pound sample thus obtained is guarded in a waterproof cover against contact with the air, and is eventually placed in

a wire cage and hung in a cylindrical oven. The cage hangs on the arm of a weighing scale in an air current, heated to 220 to 230° F., and the sample begins to lose weight by the expulsion of moisture. The loss proceeds gradually until a constant weight has been reached, and at this stage of bone-dryness the total loss is recorded.

Standards of Condition. By trade custom and the practice of the leading Conditioning Houses it is agreed that tops combed in oil may be allowed a *regain* of weight from the absolutely dry state of 19 per cent. It is important not to confuse regain with loss of weight in drying. Nineteen per cent. upon the artificially dry state means that these tops when in correct condition contain 15·97 per cent of moisture. A certificate is issued by the conditioning authority stating the marks and numbers of the packages, their gross and net weights, the weight of the sample before and after drying, and giving the correct weight at which the tops should be invoiced. Different standards of regain are allotted to different forms of material:

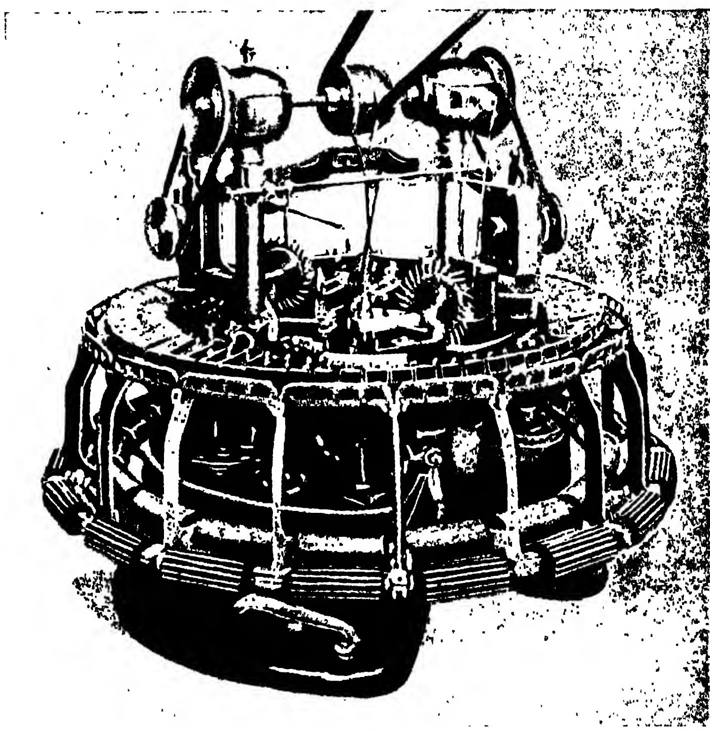
	Per cent.
Wools and waste ..	16
Tops combed in oil ..	19
Tops combed without oil	18¼
Ordinary noils	14
Scoured or carbonised noils	16
Worsted yarn	18¼
Worsted or woollen cloth	16

Tests for Oil in Tops. The practice of conditioning is applied chiefly to tops, and from 70 to 80 million pounds of them are tested in the Bradford Conditioning House annually. Water is cheaper than wool, and so is oil, for which there is also a standard, although tests for oil are more seldom made. In the usual course, a one-pound sample is made from each bag of tops requiring testing for oil, and this is divided into two halves. Each is dried in the ovens and weighed, and the samples are scoured in three or more baths of a neutral soap solution heated to 120–130° F. The samples are then re-dried, and the loss in fatty matters and dirt is indicated in the difference between the dry weights before and after scouring. The official standard for loss in scouring is 3½ per cent. for tops combed with oil and 0·634 per cent. for tops combed without oil.

Slubbing-dyeing and Recombing When it is desired to make a *mixture* yarn containing wool of more than one colour, or when for any reason it is wished to avoid *piece dyeing*, wool is sent to dye in the form of tops. The operation is known as *slubbing-dyeing*, and large quantities of material are treated at this stage. After dyeing, the tops need *recombing* to re-arrange the fibres that have been disarrayed in dyeing and to remove any broken wool or neps. The process does not differ in major respects from the ordinary combing done upon Noble machines.

The Cost of Producing Tops. The cost of combing is between 1¼d. and 3½d. per pound, charged upon the weight of top returned to the owner, and the charge is naturally highest upon those wools which make most noil. Wools are classed according to their *tear*, or proportion of top to noil, and the cost of producing tops is affected (1) by the price of the wool in its greasy state, (2) by the loss of weight on scouring, (3) the proportion of noil made, which has to be sold at less price than the top, (4) by the cost of combing.

The blending of wools of different origins complicates calculation further, and by judicious blending considerable economies are often made. Wools are blended together with an eye to the price, length and fineness of staple, strength, softness, lustre, and colour. Some are much lighter than others in relation to their bulk. The tops of different makers, although of the same nominal quality and selling at similar prices, may be widely different in character.



3. A CIRCULAR COMBING MACHINE
From a photograph by courtesy of Messrs. Taylor, Wordsworth & Co., Leeds

The Use of Noils. Tops are the raw material of the worsted spinner, while the noils are consumed by the woollen spinner in making blankets, tweeds, and hosiery yarn. Whereas tops are combed free from vegetable and foreign matter, noils contain the residue of straw and burrs not removed by the worsted carding or preparing machinery, and their fibres are tangled. They include broken, immature, and short wool, but are a valuable raw material. Noils of some qualities sell at higher prices than tops of other qualities, and, in exceptional conditions, such noils as are made in combing camel-hair and cashmere become more valuable even than the top from which they have been taken.

J. A. HUNTER

THE CYCLE OF LIMESTONE FORMATION

In the left-hand diagram, limestone, formed by organic life many millions of years ago, is being dissolved by rain water, impregnated by carbonic acid, percolating through it. The carbonic acid enables water to carry the lime in solution drip by drip to the spring, where it emerges as hard, spring water. A small part of the lime is deposited as stalactites and stalagmites at the spring head On the right, the stream, with the lime and carbonic acid in solution, is flowing into the ocean. A small part of the carbonic acid passes into the air as gas, liberating some of the lime, which sinks to the bottom as mud, but far by far the greater portion is appropriated by the myriad forms of marine life—foraminifera, coral, molluscs, crustaceans, and fishes of every kind, whose dead skeletons and shells, composed largely of lime, sink to the bottom, and become embedded in a matrix of limey mud. This mass, with time and pressure, is again converted into a limestone strata very similar to that originally dissolved by the rain.

How Sedimentary Rocks were Produced. Sandy and Clayey Rocks. Limestones. Coal. Volcanic Rocks. Metamorphism. Schists.

THE SEDIMENTARY ROCKS

WE have already seen quite clearly that the igneous rocks are the oldest constituents of the earth's crust. Since the earth once existed in the form of a nebula, or fiery cloud of warring atoms, and cooled by successive stages into the planet which we now inhabit, it is perfectly evident that there was a time when its surface consisted solely of igneous rocks—granites and basalts, and their allied families. But at present the most casual observation enables us to see that this is no longer the case.

Sedimentary Rocks. The surface of the earth is mainly covered with what we call *soil*, the product of disintegration of hard rocks by atmospheric and other agencies. This layer supports all life on the earth, because it brings forth vegetation, and so feeds animals, and, directly or indirectly, mankind. Underneath this we find a *subsoil* of very varying formation, if we examine it by driving a shaft or a borehole, or by studying the sections of the crust which are made by natural cliffs, as on the sea-coast, or by artificial cuttings for a railway line or a quarry. Sometimes the soil lies on the top of what we can recognise as an igneous rock; some of the most productive of Italian vineyards, for instance, are separated by only a thin layer of rich soil from the lava of a volcano. But more frequently the subsoil proves to be different from any of the igneous rocks that we have studied. It is non-crystalline, is arranged in definite layers or *strata*, and contains fossils, or relics of vanished forms of life. By all three characteristics, or by the two first, which are often present without the third, we then decide that this subsoil is not an igneous but a *sedimentary* rock.

It must be a product of later growth than the igneous rocks; for as the whole of the crust was once igneous, the sedimentary rocks must have been derived from these, whence they are sometimes called *derivative* or *secondary* rocks. In later chapters we shall have to study the processes by which the sedimentary rocks have been produced. First, however, we must make acquaintance with their various characteristics and the families into which they may be divided.

How Sedimentary Rocks were Produced. The classification of the sedimentary rocks is much simpler than that of the igneous rocks. They are far less varied and complicated in structure than those from which they are derived, partly because the natural agencies which have broken down the igneous rocks into these secondary products are less powerful and consequently less sweeping in operation than the agencies of heat, chemical action, and pressure which have produced the igneous rocks. The latter were compounded in the great laboratory of Nature, in the molten interior of the planet; the former came into existence on the earth's surface under the milder influence of rain, sea and rivers, frost and ice, wind and weather. It is quite natural that their forms should be less complex and their origin easier to comprehend. We shall see later how they were produced. It is enough to say here that they have all been formed of fragments broken from igneous rocks, and deposited in layers. This was generally due to the action of water, in which they were mechanically *suspended*—like the mud in a brook that runs dark and turbid after heavy rain—or chemically *dissolved*, like the salt in the sea. They are, in fact, the *detritus* of the earlier world, the broken-down relics of the primitive igneous rocks. A possible way of classifying them would be according to the nature of the agency which broke down the older rocks and rearranged them, as follows:

(*a*) *Æolian* rocks, produced by the action of wind, like the vast beds of loess which form some of the most fertile tracts of China.

(*b*) *Aqueous* rocks, formed by the agency of water. These form much the largest group, and may be subdivided, according to whether the fragments have been deposited from a condition of mechanical suspension in the water—sandstone and shale—or have been crystallised from a solution—rock salt and crystalline limestone.

(*c*) *Organic* rocks, formed by the action of life, like coral, chalk, and many limestones.

(*d*) *Volcanic* rocks, or *Tuffs*, which result from the breaking up of lavas and their ejection in fragments by volcanic eruptions.

Classification of Sedimentary Rocks. This classification deserves notice, as it gives a preliminary idea of the methods by which the sedimentary rocks were formed. But it is not a very good one, as the examples named will show. Are we to classify chalk, for instance, as an aqueous or an organic rock? It was all laid down by the water of the sea, in which its constituents were once floating. But it is also mainly composed of the remains of innumerable tiny creatures, which formed the calcium carbonate of the sea-water into shells and skeletons. Probably the most convenient classification is that which depends on the chemical composition of the rocks. We find by investigation that the sedimentary rocks are far less complicated in this respect than their igneous ancestors. The great majority

of them are composed mainly of one of four minerals—*sand, clay, lime,* or *carbon.* According to the prevalence of one or other of these substances, we may divide the sedimentary rocks into four great families: the *arenaceous* or sandy, *argillaceous* or clayey, *calcareous* or limy, and *carbonaceous* or coaly rocks. A fifth class is necessary, indeed, to contain the few sedimentary rocks which refuse to fall into one or other of these families. But that only shows that Nature declines, here as elsewhere, to work according to the strict logical distinctions of the theorist.

A short account of the chief sedimentary rocks with which the geologist has to familiarise himself may now be given. It should be supplemented by reading one of the fuller text-books, and by examination of actual specimens in a museum and in the field.

Arenaceous, or Sandy, Rocks. These are composed mainly of *sand,* which is simply an aggregate of tiny fragments of quartz—pure silica—more or less rounded, and not bound together by any cement. We are familiar with it on the sea-shore, on the margins of lakes and rivers, and by hearsay, as the soil of vast deserts in drier parts of the world. This sand is the débris of quartz rocks, granite, etc., caused by the wear and tear of ages. Sometimes the process has not been carried so far, and instead of sand we have *gravel* or *shingle,* such as collects at the bend of a river, where the current runs less swiftly and so is unable to drag it further along. It is impossible to assign any limit of size beyond which these débris cease to be débris and have to be considered as part of the original rock; but we may say roughly that sand consists of particles ranging from the size of a small pea down to impalpable powder, gravel of particles ranging from a pea to a walnut in size, whilst shingle may range from that up to blocks a foot or more in diameter. Further, a distinction has to be drawn, in practice, between *rounded* sand and pebbles such as are found on a sea-beach, where the waves have been grinding the particles against one another till all corners are worn off, and *angular* fragments of more recent origin found in a quiet spot.

29. RIPPLE-MARKED SANDSTONE
From Wealdon

The various forms of quartz detritus known as sand, gravel, shingle, and pebbles form the raw material of the chief sandy rocks. They are again united into a solid rock in two ways. The mere pressure of the superincumbent strata is often sufficient to consolidate fine particles of sand into a coherent mass—just as powdered graphite is squeezed in a hydraulic press until it forms the solid lead for our pencils. In other cases the separate particles are held together by a hard cement, or *matrix,* which may be hardened sand or clay, or chemical cement precipitated from solution in water. The numerous varieties of sandy rocks owe their countless differences to the union of different kinds of particles by different kinds of cement.

Sandstone. *Sandstone* [29] is a rock formed of consolidated sand, held together by its own coherence or by a cement, which may be of iron oxide (which gives its colour to most of the red sandstones), of clay, of carbonate of lime, of silica, or other material. Thus, we have ferruginous, argillaceous, carbonaceous, siliceous, and yet other sandstones. If the grains of sand are somewhat coarse and angular, so that the stone, when broken, feels very rough to the touch, it is known as *Gritstone.*

Greywacke is the name given to a particularly compact and hard sandstone, of a prevalent grey colour, which is the hardened muddy sand of very ancient sea-floors. *Flagstone,* used for pavements, is a sandstone which splits into thin flags along the planes of bedding or stratification. *Freestone* is a sandstone which can be cut with equal ease in any direction, and shows no such tendency to split up.

Conglomerate. This, popularly known as *pudding stone* [30], is a rock in which the sand is replaced by gravel or shingle, held together by a cement which may consist of hardened sand or clay, or of the materials mentioned in the last paragraph. The rounded pebbles, which give character to the conglomerate, may be of quartz, granite, limestone, or many other rocks.

Breccia. *Breccia* [31] is a rock in which the pebbles, instead of being rounded, as in conglomerate, are angular. The real distinction between the two is that conglomerate points to the action of water, which always tends to round pebbles exposed to its action, and breccia to atmospheric denudation (such as forms cliff screes and glacial moraines), which leaves the fragments much as they were when broken off by frost or other weathering influences.

Argillaceous, or Clayey, Rocks. These are composed of fine argillaceous sediment, derived from the waste of rocks, especially of granites and other rocks which contain the felspars as ingredients. *Clay* itself is a hydrated silicate of alumina, which is a product of the decomposition of felspar. It occurs in many varieties with differing compositions, of which *kaolin* or *china clay, pipe-clay* and *fire-clay* are well-known examples. *Brick-clay* is a name industrially given to the coarser clays. *Loam* is a mixture of clay and sand, which provides an excellent soil for many kinds of vegetation.

Loess, again, is a clay which has been accumulated probably by wind-drifts to the depth of hundreds of feet in the great river valleys of China, where it plays an important part in agriculture. *Boulder-clay*, or *till*, is a stiff, sandy clay, full of boulders of all sizes, which is found only where ancient glaciers once ground to powder all but the hardest fragments of rock, and in which these surviving fragments are still found embedded. All these, it will be remembered, are rocks in the geological, though not in the popular, sense of the word.

30. CONGLOMERATE, OR PUDDING STONE
From Woolwich and Reading Beds

Under pressure of overlying strata, ancient clays have hardened into compact rocks. *Mud-stone* is the intermediate stage between clay and rock, in the popular sense. It has no tendency to split into plates, and is easily rubbed down into mud with the aid of water. *Shale* is a general term given to any clayey rock which splits easily into thin layers ; there are countless varieties, according to what other material—as iron pyrites, sand, limestone, or carbonaceous matter—happens to be present with the clay. *Oil-shales* are used in the manufacture of paraffin. *Slate* is a hard, clayey rock which splits into thin, regular plates along its cleavage planes, which are not necessarily the same as the bedding planes that represent the original surfaces of stratification. It is much employed in buildings, owing to this convenient property.

Calcareous Rocks, or Limestones. These consist mainly of calcium carbonate. The purest example is *chalk* [32], a soft rock which often contains more than 90 per cent. of calcium carbonate. It is composed of the shells and skeletons of minute organisms which once lived in primeval seas, from whose waters they extracted the calcium carbonate, which they built up into wonderfully beautiful, though microscopic, structures, which fell down to the sea-bed when the organisms died and rotted, ultimately forming deposits of hundreds or thousands of feet in thickness during the lapse of long geological ages. By far the larger number of *limestones* are similarly of organic origin. They vary in hardness and in chemical composition so widely that it is impossible to give any account of their varieties. It must be noted that in many cases limestone, though a true sedimentary rock, presents a crystalline structure, since it is soluble in water—especially if carbonic acid be present—and may crystallise out if it is again deposited from this solution. *Marble*, as we shall see later, is a limestone which has been crystallised by heat, and belongs properly to the section of metamorphic rocks.

The *magnesian limestones*, or *dolomites*, are an important class of calcareous rocks, which consists of a mixture of calcium carbonate with magnesium carbonate. All limestones have the important property that when they are heated, or "burnt," the carbon dioxide (CO_2) is driven off as gas, and quicklime (CaO) is left behind [see CHEMISTRY]. They are easily recognised by the fact that they effervesce when acid is dropped on them, carbon dioxide being again given off and forming bubbles in the acid.

Among calcareous rocks we must note those containing phosphate of lime, which arise chiefly from organic sources, and are valuable for their use as fertilisers. These include *guano*, *bone-breccia*, *phosphatic chalk*, and the *coprolites*, or fossil excrement, which often occur in whole beds. Geologically these are of little importance, save as bearing witness to the earlier forms of life.

Carbonaceous Rocks. Carbonaceous rocks have almost all been derived from the decay of vegetable matter. They play an important part in human life as the chief sources of heat and power. Indeed, there is no rock, with the possible exception of the flint which first taught man to make himself tools, that has had so much influence on the course of human civilisation. *Peat* is the most recent form of carbonaceous rock, and can easily be recognised as recently decayed vegetation, found chiefly in boggy places. *Lignite*, or *brown coal*, is a more advanced stage in the mineralisation of vegetable matter, and occurs in strata more recent than those of the coal measures. *Coal* is a true rock, which contains 75 to 90 per cent. of carbon, along with oxygen, hydrogen, and nitrogen — the chief organism-building elements—and with impurities which are left as ash when the coal is burnt.

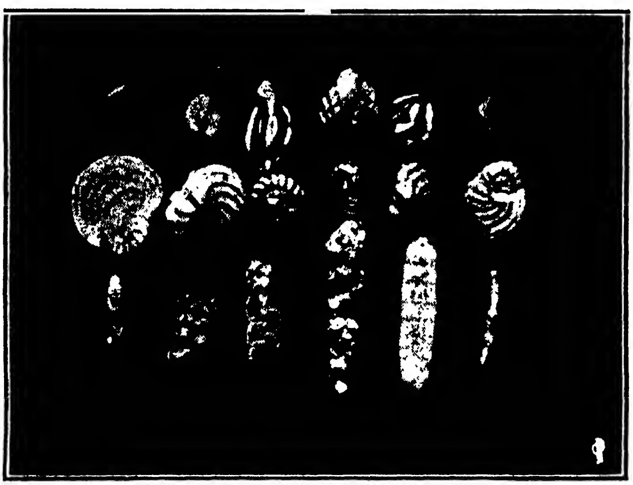
31. BRECCIA

For a special account of the numerous varieties of coal, with their special uses, the reader must consult the course on MINING. We need only mention *anthracite*, which is the most completely mineralised form of coal, and contains over 90 per cent. of carbon. The volatile constituents have been expelled

from it, probably by the near approach of intrusive volcanic rocks, so that in a sense it is a metamorphic rock. The valuable Welsh *steam-coal* is a form of anthracite. *Petroleum*, which may be termed a liquid rock—as mercury is a liquid metal—at ordinary temperatures, is also a product of decayed vegetation, possibly due to the destructive distillation of coal under great pressure in the lower strata of the crust. *Asphalt* is probably of similar origin. *Graphite* occurs in large masses in places as far apart as Cumberland and Ceylon, and must be named under this head. Its origin is not clear, but it is known to be practically pure carbon, and may thus rank as the last step in the alteration of vegetable matter.

Other Sedimentary Rocks. There are a small number of sedimentary rocks which have found no space inside this classification, but must be mentioned in the course of such a review.

Siliceous Sedimentary Rocks are of organic origin, and consist of the shells and skeletons of marine organisms which chose to build their frail houses of silica rather than of limestone. The most important of these is *flint* which consists of practically pure silica, partly amorphous and partly crystalline. It is found in nodules, usually dispersed through the chalk strata. It is believed that these nodules or lumps were formed by the chemical deposition of the silica of the sea-water around the nuclei afforded by the siliceous skeletons of dead sponges or diatoms. The great importance of flint from a human point of view lies in the fact that, though intensely hard, it can easily be chipped into shapes with sharp edges, and so lends itself more readily than any other material to the manufacture of primitive cutting instruments and weapons. It is not too much to say that the whole fabric of our civilisation is based on flint.



32. PHOTOMICROGRAPH OF CHALK
(Magnified 100 diameters)

Crystalline Sedimentary Rocks. These, though not very common, do occur. We have seen that there are two ways in which a mineral may crystallise—either by cooling from a state of fusion, or by precipitation from a solution in water or other liquid. *Diamonds* are undoubtedly formed in the latter way, by the crystallisation of carbon which has been dissolved under great pressure in molten iron. *Rock salt*, which is found in beds hundreds of feet thick, and often assumes a crystalline structure, is clearly the relic of ancient seas or salt lakes which have gradually dried up. *Limestone* is often found in a crystalline form, due to the fact that it has dissolved in water containing carbonic acid gas, and has again been deposited in crystalline form. *Travertine*, or calc-sinter, is thus deposited by calcareous springs, while the *stalactites* and *stalagmites* of limestone caverns are of similar origin.

Volcanic Fragmental Rocks. *Volcanic fragmental rocks*, or *tuffs*, though not in the strict sense of the word sedimentary rocks, are usually included in this family. They consist of the materials ejected from volcanoes otherwise than in the form of lava. They vary in size from *volcanic bombs*, often several feet in diameter, to the impalpable *volcanic dust*, which floats in the air long after an eruption and slowly settles down on the earth, where it becomes stratified just as if it had been deposited by water. *Volcanic tuffs* are rocks formed of this kind of detritus, fine or coarse, which vary, according to the nature of their materials, from a coarse *volcanic conglomerate* to a fine-grained rock. They are found, of course, only in the neighbourhood of ancient volcanoes, and usually shade off into true sedimentary formations.

Metamorphic Rocks. There is a third class of rocks which are neither igneous nor sedimentary—that is, these rocks are no longer in the original state in which they solidified from the molten core of the earth's crust, nor yet have they been broken down and arranged in strata by the action of water or atmospheric influences. They have, however, undoubtedly been altered from the condition in which they were first produced, and accordingly they are described as *metamorphic* or *altered rocks*.

Their present state bears witness to the action of many and various agencies of change. Some of them are igneous rocks which have assumed a false stratification in consequence (probably) of the pressure of superincumbent layers or of pressure exerted from the side by the great deformations due to the shrinkage of the earth's crust and its consequent wrinkling into mountain ranges. Others are sedimentary rocks which have assumed a false crystalline character through the action of heat, usually due to their coming in contact with intrusive floods

of molten lava welling up from beneath the surface—*contact* metamorphism. *Marble*, for instance, is a metamorphic rock which is now crystalline. It was once sedimentary limestone, which has been melted under great pressure and has crystallised in cooling. If we heat limestone under the normal conditions which obtain at the earth's surface, it does not melt, but the carbon dioxide passes off as gas, and lime is left behind, as occurs in every lime-kiln. But if the limestone be enclosed in a steel chamber so strong that the pressure of the escaping gas cannot burst it, it is possible to melt it, and to produce a kind of marble in our laboratories, so illustrating the process by which marble was naturally produced when vast masses of limestone sank down far beneath the earth's surface and were exposed to the central fires under the immense pressure produced by miles of superincumbent strata.

33. A MASS OF FOLDED GNEISS

False Stratification. It is not necessary to enter into a detailed account of the various metamorphic rocks, which can be arranged in a long series, where every term shades into the next one, from the argillaceous *schists* closely resembling slates to the *gneisses* which can often be distinguished from granite only with difficulty. It is enough to say that these rocks are in general characterised by a double set of qualities which stamp them as intermediate between igneous and sedimentary rocks. They are crystalline, and they are arranged in layers or strata. Close examination betrays a typical distinction between these strata and those which mark the true sedimentary or stratified rocks. In the latter case, the strata, or bedding-planes, indicate the successive layers in which these rocks were deposited by water or other agency. In the metamorphic rocks the stratification is produced in quite a different way. It is found by experiment that if a mass composed of crystals be subjected to powerful and long-continued pressure in a particular direction, the crystals which compose it tend to rearrange themselves so that all their longer axes lie in the same direction—just as the dates which have been squeezed into one of the lumps familiar in all grocers' shops are found to lie practically all in one direction. It is this rearrangement of the separate crystals which produces a false appearance of stratification in the metamorphic rocks.

Schists. A crystalline rock which has thus obtained a stratified structure as the result of pressure is known as a *schist*; it is often spoken of as being *foliated*, rather than stratified. A schist may also be the product of heat or chemical action upon a sedimentary rock, which gains a crystalline character without losing its stratified appearance. Practically all metamorphic rocks owe their origin to one or other of causes we have mentioned.

The schists are almost as numerous as the sedimentary and igneous rocks from which they are derived. Thus we have *clay-schist* and *quartz-schist*, which are both crystalline forms of clayey and sandy sedimentary rocks, while *quartzite* is a still more thoroughly crystallised sandstone. *Schistose conglomerates* are conglomerates in which pressure has produced a bedded structure by the arrangement of the pebbles into layers. *Crystalline limestone* and *marble* are also of sedimentary origin. *Gabbro-schist*, *hornblende-schist*, *mica-schist*, and the like need little explanation. *Gneiss* [33] is the term applied to the coarse schists which present characters resembling those of granite, some of which are volcanic rocks which have acquired a stratified character by alteration under pressure, while others are sedimentary rocks which have been crystallised by heat. This shows very prettily how diametrically opposed histories can end in nearly the same result in the great laboratory of Nature.

We shall now pass on to the second great division of geological study—*physical geology*, or the examination of the agencies at work to produce the sedimentary rocks which now cover the greater part of the earth, and give us our soil.

W. E. GARRETT FISHER

Air: its Pressure, Weight, and Mechanical Value. The Laws of Boyle, Dalton, and Charles. Compressed Air.

PNEUMATICS

It is rather surprising that the laws and truths which we intend to consider now were unknown until within comparatively recent times. Three hundred-odd years before the time of Christ, Aristotle brought his great mind to bear on the subject, but came to the alarming conclusion that air had no weight. Thenceforward, for close on nineteen hundred years, thing were seen as through a glass darkly. The eagerness with which gases and liquids rushed in to fill a vacuum was glibly "explained" by the phrase "Nature abhors a vacuum." In the seventeenth century that galaxy of great minds —Galileo, Guericke, Torricelli, and Pascal— wrested from Nature the great truths that underlie the questions of the pressure and elasticity of gases.

The pressure and elasticity of air (which may be taken as a typical gas) may be clearly and visibly demonstrated by simple experiments which can be easily performed by the student. If, for example, a tumbler or beaker be entirely filled with water, and a sheet of paper pressed over the mouth and the tumber inverted as in **158**, the paper remains in position, and the water in the glass. One might think that both paper and water would fall to the ground immediately the glass were inverted. This does not happen, because, great though the pressure of the water may be, the pressure of the atmosphere against the paper is still greater. If, however, the vessel be not completely filled—that is, if air be present inside—the exterior pressure is neutralised and overcome.

Expansibility of Air. The expansibility as well as the pressure of the atmosphere is illustrated in **159**. The empty flask A is fitted with a cork, through which a long piece of glass tubing passes. The end of the tube is placed beneath the surface of the water in the trough B. (If the water be coloured with a little red or black ink its movement will be more readily seen.) The two hands are then placed round the flask, as shown in the illustration, and the heat they impart to the air contained in the flask causes it to expand and escape, as will be seen by the stream of bubbles which rises through the water. When the hands are removed, and the flask and its contained air resume the ordinary temperature, water will rise from the trough and up the tubing towards the flask. The liquid rises against the force of gravity, because the pressure of the atmosphere acts on the water surface, is transmitted upwards through the tubing, and so causes the liquid to fill the space which was occupied by the expelled air. If the flask were gently heated with a Bunsen flame, the results would, of course, be still more pronounced.

Measuring Air Pressure. The experiments just described prove that the atmosphere has weight, but give us no idea of its amount. A means of measuring that weight is shown in an experiment first performed by Galileo's pupil Torricelli, and since repeated millions of times in the schools, colleges, and laboratories of the world. A pump had been sunk at Florence, but the water obstinately refused to rise above 33 ft. Galileo was consulted, and he concluded that the air had weight, and that a column of water 33 ft. in height was as much as the weight of the atmosphere could balance. Afterwards his disciple Torricelli studied the question. Taking a glass tube about 3 ft. long and closed at one end, he filled it with mercury. The tube was inverted, the open end being temporarily closed with the finger [**160** A], and placed below the surface of mercury in a vessel (B) [**161**]. Immediately the mercury in the tube dropped to a height of 30 in. above the level of the mercury in the vessel. A vacuum (called the Torricellian vacuum) was produced (CD). The only possible conclusion was that this 30-in. column of mercury was balanced by the atmospheric pressure.

A cubic inch of mercury weighs ·49 lb., and $30 \times {\cdot}49 = 14{\cdot}7$ lb. Therefore, as the atmosphere supports a column of mercury whose weight is 14·7 lb., and whose base measures a square inch, we are driven to the conclusion that the pressure of the atmosphere amounts to 14·7 lb. on every square inch. And this pressure, as in the case of water, acts equally in all directions. Mercury being 13·6 times heavier than water, the atmosphere would support a column of water equal in height to $30 \times 13{\cdot}6$ in., or $\frac{30 \times 13{\cdot}6}{12}$ ft. $= 34$ ft. This explains why water refuses to rise to a greater height than this (in practice not more than 25 ft.) in a common lift-pump; hence also the need of a liquid of high specific gravity for use in a barometer.

To this pressure of the atmosphere, then, we are indebted not only for the action of the barometer but also for the action of the various types of water-pumps [see page 1563]. It has, however, been thought fit to deal with pumps under HYDROSTATICS, for the reasons stated in that section.

Boyle's Great Discovery. In the history of every science there are records of remarkable cases of simultaneity in discovery. An example of this occurs in the subject now under consideration. In the latter half of the seventeenth century, Robert Boyle, in England, and Edme Mariotte, in France, were both studying the effect of pressure applied to a gas. Their investigations led each to arrive

independently at the same great truth, and so nearly simultaneous was the discovery of the law that in England it is known as Boyle's Law, on the Continent as Mariotte's Law, and sometimes as Boyle and Mariotte's Law. There seems, however, no doubt that the great English, or rather Irish, physicist was first. Boyle's Law may be stated: *The volume of a gas varies inversely as the pressure, temperature remaining unaltered.* Thus, if at a pressure P the volume of a given quantity of a gas be V, and the volume changes to V′ at a pressure P′, then P : P′ : : V′ : V. The product of the extremes being equal to that of the means, PV = P′V′, or $\frac{P}{P'} = \frac{V'}{V}$.

If in **162** A and B represent the same cylinder with the piston in the two positions shown, then the pressure when the piston is at DE is to the pressure when at D′E′ as the space C′D′E′F′ is to the space CDEF. The reader will now see how highly important this law is in engineering, for, translated into technical parlance, it tells us that in the steam in an engine cylinder, the gas in a gas-engine, and the air in an air-engine, as long as temperature is unchanged, the pressure, or elastic force, varies inversely as the volume occupied by the gas.

Verification of Boyle's Law. The law may be verified by means of a long bent tube, as in **163**. Mercury is poured in at A (or at C, and this opening then closed) until it stands at the same level B—B in both branches. Then the air in the closed portion (BC) is at the pressure of the atmosphere. By pouring more mercury into the tube at A, the air in BC gradually becomes more and more compressed, owing to the increased pressure in the long branch. Both the decreasing volume of the air and the increasing pressure of mercury producing it may be measured, and the results tabulated. In a uniform tube such as this the volume is proportional to height, so that a finely divided scale is all that is necessary for measuring volume and pressure. For the total pressure in each case, the height of the mercury in the long branch above the level of that in the short one must be added to the pressure of the atmosphere, as indicated by the barometer at this particular time, for the pressure of the air in BC is evidently equal to the sum of these two. If, for example, the air be compressed to occupy the space B′C the height B′E would be added to the barometer height.

The table on this page shows a series of readings so taken. The first column gives the level (in centimetres) of the mercury in the short branch, and this, subtracted from 26 centimetres—the total height of this limb—gives the height of the enclosed column of air.

The third column in this table shows the height of mercury in the long limb, and the difference between this and the level in the short one gives the pressure stated in column four. But the enclosed air is subjected not only to this pressure, but also to the additional pressure of the atmosphere, in this case 76·57 centimetres. Thus the total pressure is that in the fifth column.

Air.		Mercury.			
Level of mercury A	Height of air in short limb, 26 cms. − A = V	Height of mercury C	Difference in level of mercury, C − A = D	Total pressure, 76·57 + D = P	Constant, V × P = K
2·2	23·8	2·2	—	76·57	1822
2·8	23·2	4·75	1·95	78·52	1822
3·2	22·8	6·4	3·2	79·77	1819
4·15	21·85	10·75	6·6	83·17	1817
5·55	20·45	17·75	12·2	88·77	1815
6·95	19·05	25·7	18·75	95·32	1816
8·0	18·0	32·4	24·4	100·97	1817
9·9	16·1	46·0	36·1	112·67	1814
11·6	14·4	60·7	49·1	125·67	1810
12·6	13·4	71·2	58·6	135·17	1811
				Average	1816

Pressure and Volume. On comparing the tabulated results the truth of the law will be evident. A glance shows that as the pressure (P) increases, the volume (V) decreases, and the ratio in which this occurs is seen by taking any two pressures and corresponding volumes. Thus the pressure 125·67 is roughly one and a half, or $\frac{3}{2}$ times 83·17. But the volume corresponding with the first-named pressure is approximately $\frac{2}{3}$ of that at the second pressure. Similarly, with more extended investigations it would be found that with twice the pressure the volume is halved; with 3, 9, 12, 50, or n times the pressure, the volume is reduced to $\frac{1}{3}, \frac{1}{9}, \frac{1}{12}, \frac{1}{50}$ or $\frac{1}{n}$ of the original volume. Moreover, the number (K), obtained by multiplying together the volume and the pressure in each case, varies but little from the same product in the other lines. This slight variation is explained by trifling errors of experiment. This fixed value of V × P enables us to state the law thus: *Temperature being constant, the product of the pressure and volume of a gas is a constant.* If one be known, the other is easily found by reducing the law to the formula: *Pressure × volume = constant.* The product remains unchanged, and the two factors vary, just as, for example, half a dozen different rectangles might all contain 64 sq. in., yet their sides could be in inches: 64 × 1, 32 × 2, 16 × 4, 8 × 8, 12·8 × 5, 6·4 × 10.

Investigations with pressures less than that of the atmosphere also verify the law.

Behaviour of a Gas. The story of the behaviour of a gas under varying pressures may be told in a more attractive manner by means of a graphic representation. The pressures and volumes in the table may be plotted as in **164**, where the bottom (AC) is figured for horizontal line volumes, and the vertical line (AB) for pressures. Then the story is told by the curve. As it extends in the direction of C—that is, as the volume increases—the curve sweeps downwards; in other words, the pressure falls; or, as the curve rises the volume decreases

and pressure increases. At the point P the volume is about 14, and the pressure 125 centimetres; at the point P′ the volume is 18, and the pressure 100 centimetres. With a wide range of pressures and volumes [165], it will be seen that the curve, though it approaches nearer and nearer to the lines of volumes and pressures, never touches either. The reason for this is clear when we consider that no increase of pressure can bring the volume to zero, and no increase of volume can reduce the pressure of a gas to a vanishing point. It would thus be impossible for this line to be straight, for then it would eventually cut both the line of volumes and of pressure.

Curve of Volume and Pressure. Since the product of the volume and pressure of a gas is constant, this curve exhibits another useful property. If we take any three points, as X, Y, Z [165], then at X the pressure is represented by XE, and the volume XI; at Y, pressure = YG, and volume = YH; at Z, pressure = ZF, and volume = ZD. Therefore, the areas XIAE, YHAG, ZDAF, are all equal; and this would be the case with a point taken at any position on the curve. Because of this property the curve is known as a rectangular hyperbola. Thus the position of any point indicates the two factors volume and pressure, and if one be known the other is immediately found. For if we are given a volume which, according to the scale adopted, equals AF, then by laying this distance along the line of volumes AB, and erecting a perpendicular at F, the pressure is seen to be equal to FZ, or, by referring to the scale chosen, AD.

Referring again to the diagram, if Z marks the first and X the final condition of the gas, then the actual diminution in volume is represented by ZK, and the increase of pressure by KX. The work done by the pressure in changing the volume from AF to AE is represented by the area of the figure ZXEF.

The Law of Dalton. When two or more gases of different kinds are mixed together—and this sometimes occurs, as in the case of air and water vapour in the air-pump of a condensing engine—*the total pressure exerted by the mixture is equal to the sum of the pressures exerted by the different gases.* In other words, each gas exerts its own pressure just as though no other gas were present. This is, in reality, a general law, of which Boyle's Law is a particular case—a fact which will be readily seen on comparing the statement above with that of Boyle's Law as simplified by Professor Rankine: "If we take a closed and exhausted vessel, and introduce into it one grain of air, this air will, as we know, exert a certain pressure on every square inch of the surface of the vessel. If we now introduce a second grain of air, then the second grain will exert exactly the same pressure on the sides of the vessel that it would have exerted if the first grain had not been there before it, so that the pressure will now be doubled. Hence we may state, as the property of a perfect gas, that any portion of it exerts the same pressure against the sides of a vessel as if the other portions had not been there."

The Question of Temperature. The general effect of heat on solids, liquids, and gases is to cause expansion, and, as a rule, gases expand more than liquids, and liquids more than solids. And it is a well-known fact—a matter of common observation—that if equal increments of temperature be applied to a number of solids (say, rods of copper, iron, zinc), or to a number of liquids (water, alcohol, mercury), there is a considerable difference between their relative expansion, whereas with all gases and vapours expansion proceeds at the same rate when heated through the same interval of temperature. Thus the second great law of gases runs: *The volume of a gas under constant pressure expands, when heated, by the same fraction of itself,* whatever be the nature of the gas (the Law of Charles). What is this fraction?

Experiment has shown that 1000 volumes of air at 0° C. become 1366·5 volumes at 100°—*i.e.*, 1 volume of 0° increases to 1·003665 at 1°. The amount of increase in volume for 1°, ·003665, approximately equals $\frac{1}{273}$, and so this fraction is called the coefficient of expansion for air. Thus, for every increase of 1° C., the volume of the gas is increased $\frac{1}{273}$ of its volume. Therefore, 1 cub. in. of a gas at 0° C., when raised to

$$1^\circ = 1 + \frac{1}{273} \text{ cub. in.}$$

$$2^\circ = 1 + \frac{2}{273} \quad ,, \quad ,,$$

$$30^\circ = 1 + \frac{30}{273} \quad ,, \quad ,,$$

$$n^\circ = 1 + \frac{n}{273} \quad ,, \quad ,,$$

Therefore, 273 volumes at 0° are changed to 274 volumes at 1°, 275 volumes to 2°, and so on.

Volume Reduced by Lower Temperature. Now, as the gas expands uniformly with uniform increments of temperature, it follows that with uniform *reduction* of temperature the gas should decrease in volume by uniform fractions of itself—that is, for every degree through which the gas is cooled below 0° C., it should lose $\frac{1}{273}$ of its volume. Then it follows that if cooled through 273 degrees below zero, the gas would theoretically occupy no volume whatever. Such a temperature has never yet been reached, but it is pretty certain that a gas would cease to exist as such at this low temperature. This theoretical point, −273° C., is therefore called the absolute zero of temperature, and when reference is made to "absolute temperature" it means that the temperature is reckoned from this absolute zero. Absolute temperatures are obtained by adding 273° to the C. reading. If it be the temperature on the C. scale, then absolute temperature = t + 273°. This conception of absolute temperature enables us to connect the two great laws which govern the behaviour of gases: *In a gas the volume (at constant pressure) or the pressure (at constant volume) is proportional to the absolute temperature.* Or, the product of the pressure and volume

is proportional to the absolute temperature. If V equals the volume of a gas; P the pressure; and T the absolute temperature, then the ratio $\frac{VP}{T}$ is constant for that gas for all volumes of V, P, and T.

Practical Importance of Temperature. In making the observations on which the table verifying Boyle's Law was constructed, and from which the curve in **164** was plotted, pressure and volume only were considered, temperature remaining constant. But as far as engineering is concerned, temperature *does* invariably enter into the question; so that when we come to consider the behaviour of steam in the engine-cylinder, or air in an air-compressor, for example, the problem becomes more complicated. When a gas suffers compression, heat is produced; and unless the pressure is gradual and long continued, the heat produced will be unable to pass away by conduction. It is then evident that the curve traced to show the relations between pressure and volume *when temperature is constant* will not coincide with the curve produced when the heat caused by compression is not allowed to escape. For any gas a number of curves may be traced, each at a different but constant temperature, and these are called *isothermal* lines (Gr., *isos*, equal; *therme*, heat). So far, we have considered only changes in volume and pressure which have taken place isothermally, and the curves in **164** and **165** are isothermal curves.

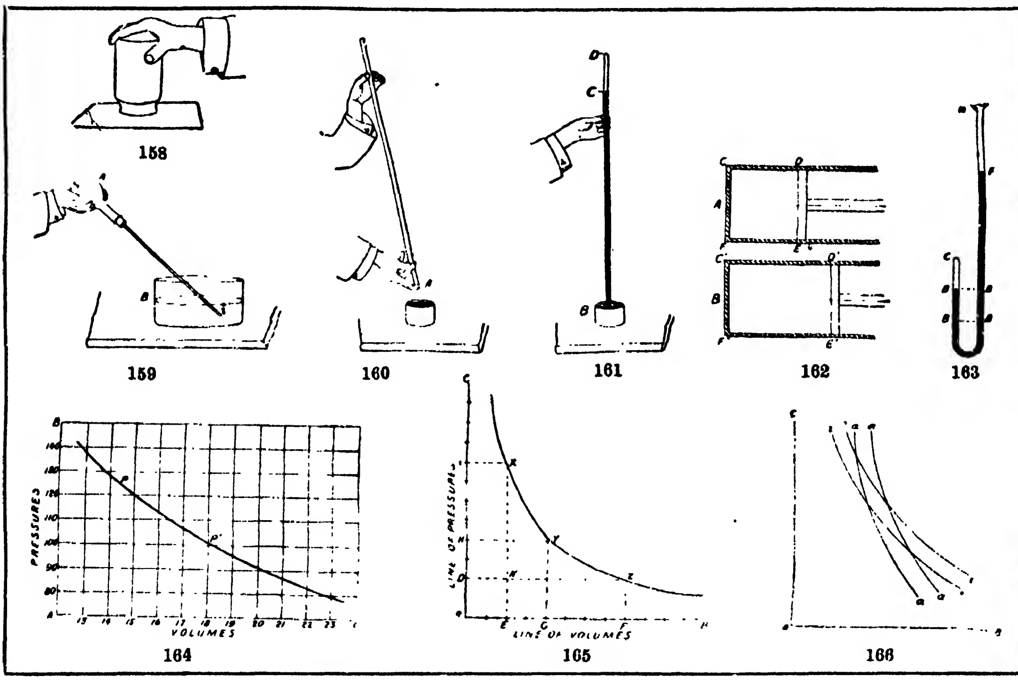
When, however, a gas is compressed, and expands under conditions which prevent any heat passing in or out of the chamber containing it, its behaviour would be represented by a line which would pass from one isotherm to another. Such lines are called *adiabatic* (Gr., *a*, privative prefix; *dia*, through; *baino*, I go). In **166** *i*, *i* are isothermal lines, *a*, *a* are adiabatic lines. The most striking feature about these curves, as compared with the isothermal lines, is the relatively greater angle which they make with the horizontal line AB. This means that a much greater increase of pressure is necessary to diminish the volume of a gas when under adiabatic conditions than when acting isothermally. For a definite increase in pressure the volume will be greater when no heat enters or escapes than when the case is otherwise—a fact which is shown by the diagram.

Compressed Air. Though free air—that is, at atmospheric pressure—is utilised by engineers, air when compressed also becomes a motive power of very great value. Its applications have grown enormously in recent years. To name only a few, miners' rock-drills are actuated thus; mine locomotives and coal-cutters also are driven by air. Sunken vessels are raised; hammering, chipping, caulking, riveting, tapping, etc., are effected; parcels are transmitted through tubes, and loads are lifted by cranes.

When air is compressed, this is done by the movement of a piston in a cylinder, the average amount of pressure for ordinary purposes being usually 60 to 80 lb. per square inch. When higher ones are required, the work is done in two or three stages, and for some purposes pressures of 500 lb. and more are employed. When air is compressed thus, and made to do work, it does so by virtue of its expansion.

A number of practical examples of the applications of compressed air are given under PORTABLE TOOLS.

J. G HORNER



158–166. ILLUSTRATIONS OF AIR PRESSURE

Spanish: The Past Definite and the Numbers. French: Personal Pronouns. German: Numerals and Strong Verbs.

SPANISH

Continued from page 2115

By José Plá Cárceles, B.A.

Past Definite. The past definite of regular verbs is formed by adding to the stem of first conjugation verbs the terminations *é, aste, ó, amos, ásteis, aron;* and of second and third conjugation verbs the terminations *í, iste, ió, imos, ísteis, ieron.*

PAST DEFINITE

Singular

I bought	I drank	I fulfilled
compr-é	*beb-í*	*cumpl-í*
compr-aste	*beb-iste*	*cumpl-iste*
compr-ó	*beb-ió*	*cumpl-ió*
	Plural	
compr-amos	*beb-imos*	*cumpl-imos*
compr-ásteis	*beb-ísteis*	*cumpl-ísteis*
compr-aron	*beb-ieron*	*cumpl-ieron*

The past definites of (1) *ser*, (2) *estar*, (3) *tener*, and (4) *haber* are irregularly formed, and run as follow:

Singular

(1) I was	(2) I was	(3) I had	(4) I had
fuí	*estuve*	*tuve*	*hube*
fuiste	*estuviste*	*tuviste*	*hubiste*
fué	*estuvo*	*tuvo*	*hubo*
	Plural		
fuímos	*estuvimos*	*tuvimos*	*hubimos*
fuísteis	*estuvísteis*	*tuvísteis*	*hubísteis*
fueron	*estuvieron*	*tuvieron*	*hubieron*

EXERCISE XXVIII

to cost	*costar*	all	*todo*
to take	*tomar*	the last	*el último*
to greet	*saludar*	contractor	*contratista*
to agree	*acordar*	Christmas	*Pascua*
to travel	*viajar*	the night	*la noche*
to last	*durar*	a journey	*un viaje*
regiment	*regimiento*	bay	*bahía*
about	*respecto á*	battle	*batalla*
fortress	*fortaleza*	soon after	*poco después*
according to	*según*	the wharf	*el muelle*
by storm	*por asalto*	a song	*una canción*
a couple of	*un par de*	at least	*por lo menos*

how long?	*¿ cuanto tiempo ?*
later than ever	*más tarde que nunca*
a return ticket	*un billete de ida y vuelta*
in the middle of	*en medio de*
to cast anchor	*anclar*
as far as	*hasta*

1. Did you understand the song? 2. No; she sang in Italian that night. 3. We waited at least two hours. At what time did the train arrive? 4. Later than ever. Nearly at half-past eight. 5. How much did the journey cost you? 6. I took a return ticket, which is much cheaper. 7. When did the contractors begin to build the wharf? 8. I think they began soon after Christmas. 9. Did you check all the invoices? 10. No; I had no time to check them all. 11. Did it rain? 12. Only in the evening. 13. Did they wait at home? 14. No; they went out to greet him. 15. Where did the steamer cast anchor? 16. In the middle of the bay. 17. I do not understand why they did not answer my telegram at once. 18. Do you know what they decided about the journey? 19. Yes; they agreed to travel with him as far as Vigo. 20. How long did the battle last? 21. A couple of hours. According to the last news, two regiments took the fortress by storm. 22. You speak English very well. Where did you learn it? 23. I was nine months in London, where I had a very good teacher.

Cardinal Numbers: The cardinal numbers are as follow:

1.	*uno*	31.	*treinta y uno*
2.	*dos*	32.	*treinta y dos*
3.	*tres*	33.	*treinta y tres*, etc.
4.	*cuatro*	40.	*cuarenta*
5.	*cinco*	50.	*cincuenta*
6.	*seis*	60.	*sesenta*
7.	*siete*	70.	*setenta*
8.	*ocho*	80.	*ochenta*
9.	*nueve*	90.	*noventa*
10.	*diez*	100.	*ciento*
11.	*once*	101.	*ciento uno*
12.	*doce*	102.	*ciento dos*, etc.
13.	*trece*	200.	*doscientos*
14.	*catorce*	300.	*trescientos*
15.	*quince*	400.	*cuatrocientos*
16.	*dieciseis*	500.	*quinientos*
17.	*diecisiete*	600.	*seiscientos*
18.	*dieciocho*	700.	*setecientos*
19.	*diecinueve*	800.	*ochocientos*
20.	*veinte*	900.	*novecientos*
21.	*veintiuno*	1,000.	*mil*
22.	*veintidos*	2,000.	*dos mil*, etc.
23.	*veintitres*, etc.	100,000.	*cienmil*
30.	*treinta*	1,000,000.	*un millón*

2,000,000 *dos millones* 100,000,000 *cien millones*

Rules for Numbers. These numbers have no gender except *uno* and *doscientos, trescientos*, etc., which change the final *o* into *a* before a feminine substantive.—*dos libros*, two books; *dos casas*, two houses; but *doscientos soldados*, 200 soldiers; *doscientas enfermeras*, 200 nurses.

Uno and *ciento* in front of a noun or adjective are contracted to *un* and *cien* respectively.—*un peso*, one dollar; *cien caballos blancos*, one hundred white horses.

Tens of hundreds cannot be used in reading Spanish figures. Therefore the numbers 1100, 1200, 1300, etc., must be invariably rendered by *mil ciento, mil doscientos, mil trescientos*, etc.

The preposition *de* is always added to the word *millón* and its plural *millones* when the substantive immediately follows.—*dos millones de francos*, 2,000,000 francs. Before *ciento* and *mil* the word *un* is never used, but 1,000,000 is invariably read as *un millón*.

How to Express "Age." The age of a person is expressed by "to have years," instead of "to be old." The question "How old is she?" is therefore rendered by "*¿Cuantos años tiene ella?*" (literally, "How many years has she?") "She is twenty-two" should be translated accordingly by "*Tiene veintidos años.*" The question may also be put in this manner: "*¿Que edad tiene?*" (lit., "What age has she?").

EXERCISE XXIX

to command	*mandar*	killed	*muerto*
a shilling	*un chelín*	wounded	*herido*
to amount	*ascender*	prisoner	*prisionero*
the page	*la página*	customs	*aduanas*
to discover	*descubrir*	the area	*el área*
a pound	*una libra*	Columbus	*Colón*
to estimate	*calcular*	the enemy	*el enemigo*
the mine	*la mina*	the losses	*las bajas*
a gun	*un cañón*	a ship	*un buque*
a frigate	*una fragata*	Europe	*Europa*
annual	*anual*	between	*entre*
production	*producción*	equivalent	*equivalente*

a case of sugar	*una caja de azúcar*
land surface	*superficie territorial*
net receipt	*ingreso líquido*
square mile	*milla cuadrada*

1. Twenty ships. 2. Fifty-three shillings. 3. Seventy-nine pages. 4. Forty-five cases of sugar. 5. One hundred and seven pounds. 6. Three hundred and sixty-five days. 7. Six hundred and thirteen trees. 8. How old is he now? 9. He is seventy-five years old. At (trans., at the) twenty-three years of age he commanded a frigate of eighty-four guns. 10. What age were (imperfect) you then? 11. I was fifteen years old. 12. In 1700 Davenant estimated the annual production of all the mines of England (at) between seven and eight hundred thousand pounds. 13. The area of Canada is 3,470,000 square miles, which is nearly equivalent to the land surface of Europe. 14. The enemy's losses were 1050 men killed, 1700 wounded, and 2500 prisoners. 15. In 1844 the net receipt of the Customs at (trans., *de*) Liverpool amounted to £4,365,526 1s. 8d.

The Ordinal Numbers. The ordinal numbers agree in gender and number with the following noun and are as follow:

1st *primero*	13th *décimo tercio*
2nd *segundo*	14th *décimo cuarto*, etc.
3rd *tercero*	20th *vigésimo*
4th *cuarto*	21st *vigésimo primo*
5th *quinto*	22nd *vigésimo segundo*
6th *sexto*	30th *trigésimo*
7th *séptimo*	40th *cuadragésimo*
8th *octavo*	50th *quincuagésimo*
9th *noveno, nono*	60th *sexagésimo*
10th *décimo*	70th *septuagésimo*
11th *undécimo*	80th *octogésimo*
12th *duodécimo*	90th *nonagésimo*

100th *centésimo*.

After "the tenth," cardinal numbers are generally used instead of the ordinal numbers.—*el tomo quince*, the fifteenth volume.

The days of the month, which in English are expressed by ordinals, are rendered in Spanish by the corresponding cardinal numbers with the only exception of "the first," which is nearly always translated by *el primero*.—*el 17 de Enero*, the 17th of January.

Ordinals may be placed before or after the noun they qualify, but the cardinal numbers must always follow the substantive; thus, the second lesson, *la segunda lección*, or *la lección segunda*, but "the 25th lesson" must be rendered by *la lección veinticinco*.

Whenever the masculine ordinal numbers *primero* and *tercero* are placed in front of the noun, the final *o* must be dropped.—*el primer capítulo*, the first chapter, but *el capítulo primero*.

With the names of kings, popes, and the like the ordinals must be used up to the 10th. Beyond this figure the cardinal numbers are commonly employed. In sentences of this kind the article is invariably omitted; thus, Edward VII., *Eduardo Séptimo*; Alphonse XIII., *Alfonso Trece*.

Fractions. "One half" and "one third" are respectively rendered by *la mitad* or *un medio* and *un tercio*. From $\frac{1}{4}$ up to $\frac{1}{10}$, fractional numbers are expressed by ordinals, but beyond $\frac{1}{10}$ the terminations *avo, avos* must be affixed to the corresponding cardinal numbers. The decimal units 0·01, 0·001, 0·0001, and so on, are rendered by *una centésima, una milésima, una diezmilésima*.—*dos quintos*, $\frac{2}{5}$; *cinco catorceavos*, $\frac{5}{14}$; *tres milésimas*, ·003.

The most important numerical substantives and adjectives are the following:

a couple	*un par*	fourfold	*cuádruple*
ten	*una decena*	fivefold	*quíntuple*
a dozen	*una docena*	sixfold	*séxtuple*
a thousand	*un millar*	tenfold	*décuple*
double	*doble*	hundredfold	*céntuple*
threefold	*triple*	manifold	*múltiple*

a hundred *una centena* or *un centenar*

EXERCISE XXX

to land	*desembarcar*	the class	*la clase*
to be born	*nacer*	a building	*un edificio*
to ascend	*ascender*	the floor	*el piso*
to expire	*expirar*	the library	*la biblioteca*
to contain	*contener*	a volume	*un tomo*
to remain	*permanecer*	a chapter	*un capítulo*
same	*mismo*	the wife	*la esposa*
exclusive	*exclusivo*	the date	*la fecha*
Spain	*España*	a port	*un puerto*
England	*Inglaterra*	the tonnage	*el arqueo*
Italy	*Italia*	a ton	*una tonelada*
Charles	*Carlos*	the vessel	*el barco*
the king	*el rey*	stationary	*estacionario*
the pope	*el papa*	the right	*el derecho*
the throne	*el trono*	a quarter	*un cuarto*
a kingdom	*un reino*	per	*por*
the reign	*el reinado*	an inch	*una pulgada*
a century	*un siglo*	at the close	*al final*
foot	*pie*	the birth	*el nacimiento*

the New World	*el Nuevo Mundo*
without reckoning	*sin contár*
the birthday	*el cumpleaños*
the population	*la población*
the rate	*la proporción*
an emperor	*un emperador*
the inhabitant	*el habitante*
not a single provincial town	*ni una sola ciudad provinciana*

1. He smokes a couple of pipes after dinner. 2. I used to travel (in) third class. 3. They are living now on the fifth floor of the same building. 4. I read it in the first chapter. 5. Did you lend him the 20th volume of the Spanish library? 6. We landed at Valparaiso on the 21st of December (of), 1879. 7. His wife was born on the 6th of January, 1886. 8. August the 30th will be her first son's birthday. 9. What date is today? 10. The 19th of February. 11. Philip III. ascended to the throne of Spain in 1598. 12. In 1493 the Pope Alexander VI. granted to the Catholic kings exclusive rights over the New World. 13. The Emperor Charles V. expired (on) the 21st of September, 1558, at the age of 58 years 6 months and 25 days. 14. At the close of the 17th century the population of England was (*era*) 5,200,000 souls. 15. The tonnage of the steamers of the port of London amounted, at the close of 1854, to 138,000 tons, without reckoning vessels of less than fifty tons. 16. In the reign of Charles II., Macaulay writes, not a single provincial town in the (trans., *del*) kingdom contained (impf.) 30,000 inhabitants, and only four had (impf.) 10,000. 17. During a quarter of (a) century the rate of births in Italy remained almost stationary, at 37 per 1000. 18. One inch is equal to 1-12th of (a) foot. 19. 0·04563.

Key to Exercise XXIV

1. Las cinco. 2. Las diez. 3 Las dos menos cuarto. 4. La una y media. 5. Eran las once menos cinco (minutos). 6. Serán entonces las tres. 7. Las diez menos dieciseis. 8. ¿ Qué hora es? 9. Son las cuatro. 10. Mi reloj está cinco minutos adelantado. 11. El reloj de la estación está siempre atrasado. 12. Estaré allí á las diez en punto. 13. Una semana tiene siete días y un año doce meses. 14. ¿ Es ya la una? 15. Todavía no. 16. ¿ A que hora es la cena? 17. Poco después de las siete. 18. ¿ A que hora terminará la función? 19. A las ocho en punto. 20. ¿ Puede Vd decirme la hora? 21. Con mucho gusto; son las diez menos diez.

Key to Exercise XXV

1. Let us keep it. 2. Sell them to her. 3 Let them type it. 4. Do not lend it to him (*or* to her). 5. Let him learn it by heart. 6. Do not speak so fast. 7. Let him speak. 8. Do not buy it in that shop. 9. Let her sing. 10. Let us ask. 11. Let them not sign them yet. 12. Pardon me. 13. Do not let us wait for them. 14. Be ready on Tuesday. 15. Let us have confidence in the future. 16. Do not forget it.

Key to Exercise XXVI

1. Tráigamelo Vd. 2. Vendámoselos (á ella) 3. Dispense Vd, ¿ donde está la parada de coches más próxima? 4. Pregúnteselo Vd. á un policía. 5. No los pidamos todavía. 6. ¿ Por qué no? 7. Por que tenemos otra cosa que hacer por ahora. 8. Haga el favor de escribir á máquina esas dos cartas. 9. Déjelo Vd. salir. 10. No venga Vd. antes de las siete. 11. Haga Vd. el favor de poner este vaso en mi mesa. 12. Que paguen sus dendas. 13. Elija Vd. uno. 14. Dígame Vd. cual es el más barato. 15. Vaya Vd. enseguida y explíqueselo (á ella). 16. Pruebe Vd. á repetirlo. 17. Que traduzcan el cablegrama en el acto. 18. Busquémoslo en el jardín. 19. No sea Vd. impaciente.

Continued

FRENCH

Continued from page 2111

By Louis A. Barbé, B.A.

PERSONAL PRONOUNS

1. There are two forms of personal pronouns (*pronoms personnels*): the conjunctive form and the disjunctive form.

Conjunctive Personal Pronouns. The conjunctive personal pronouns are always closely joined to a verb, and can be used only when the verb is actually expressed—not understood. Used as subjects they are:

1st person: *je*, I; *nous*, we.
2nd person: *tu*, thou; *vous*, you.
3rd person: *il*, he, it; *elle*, she, it; *ils*, (m.), *elles* (f.), they.

The conjunctive personal pronouns as objects, both direct (accusative) and indirect (dative) are:

1st person: *me*, me, to me; *nous*, us, to us.
2nd person: *te*, thee, to thee; *vous*, you, to you.
3rd person (direct): *le*, him, it; *la*, her, it; *les*, them (mas. and fem.).
3rd person (indirect): *lui*, to him, to her, to it; *leur*, to them (mas. and fem.).

2. The conjunctive personal pronouns as subjects precede the verb: *je parle*, I speak; *il ne parle pas*, he does not speak.

Exceptions: (*a*) In interrogations and exclamations the pronoun comes after the verb: *avez-vous*, have you? *parlent-ils*, do they speak? When, in the third person singular, the verb ends with a vowel, a *-t-*, with a hyphen before and after it, is inserted between the verb and the subject: *parle-t-il*, does he speak; *a-t-elle*, has she?

(*b*) The subject follows the verb, when that verb refers to what has been expressed in direct speech: *Sortez, dit-il*, go out, said he. This inversion is optional in English, but obligatory in French, and also takes place when the subject is a noun: *viens ici, dit mon père*, come here, said my father.

(*c*) The subject follows the verb in sentences beginning with *aussi*, therefore, *peut-être*, perhaps; *encore*, even then, etc.: *Il secourut toujours l'infortune; aussi a-t-il à son tour trouvé*

des amis; He always relieved misfortune; therefore he, in his turn, has found friends.

3. The conjunctive personal pronouns as objects (accusative or dative) always precede the verb, except when the verb is in the imperative: *je les vois,* I see them; *il me l'a donné,* he has given it to me; but, *donnez-le-lui,* give it to him.

When the verb is in the imperative affirmative, the disjunctive forms *moi, toi* are used instead of *me, te; donnez-le-moi,* give it to me; *prêtez-lui votre canif,* lend him your penknife (see **7**).

As a conjunctive pronoun, *lui* is both masculine and feminine; thus, *je lui parle* is both I speak to him, and I speak to her; *donnez-lui,* give him, and give her.

4. When a verb has the same person for both subject and object, it is said to be reflexive (*réfléchi*), and the personal pronouns used as objects become reflexive pronouns. There is then a special form, *se,* for the third person, singular and plural. These reflexive personal pronouns are:

me, myself, to myself; *nous,* ourselves, to ourselves.
te, thyself, to thyself; *vous,* yourselves, to yourselves.
se, himself, to himself; herself, to herself.
se, themselves, to themselves (mas. and fem.).

Examples: *Je me flatte,* I flatter myself; *tu te trompes,* thou art mistaken; *il se couche,* he goes to bed; *nous nous levons,* we get up; *vous vous habillez,* you dress; *ils* (*elles*) *s'amusent,* they enjoy themselves.

5. *En* and *y* are pronouns used more particularly, the latter almost exclusively, with reference to inanimate objects. They may be considered as equivalent to English neuter forms. *En* means "of it," "of them," "some." *Y* means "to it," "to them," and also "to that place," *i.e.* "there."

6. When a verb has several pronouns as objects, the order in which they are to be placed is as follows:

1st, *me, te, se, nous, vous;* 2nd, *le, la, les;* 3rd, *lui, leur;* 4th, *y;* 5th, *en.*

Examples: *Il me le donne,* he gives it to me; *nous les leur prêtons,* we lend them to them; *nous nous y sommes consacrés,* we have devoted ourselves to it; *vous m'en avez parlé,* you have spoken to me about (of) it; *ils lui en ont donné,* they have given him some.

7. If the verb be in the imperative and affirmative, the pronominal objects follow it, in the same order as in English. *Me* and *te* then become *moi* and *toi;* and *m', t',* before *en.*

Examples: *Donnez-le-moi,* give it to me; *prêtez-les-leur,* lend them to them; *donnez-m'en,* give me some; *pensez-y,* think of (to) it.

8. If the imperative is negative, this change does not take place, and the pronouns remain before the verb.

Examples: *Ne le leur donnez pas,* do not give it to them; *ne m'en parlez pas,* do not speak to me about (of) it; *ne vous y opposez pas,* do not oppose (yourself to) it.

9. The following table shows the relative position of all the conjunctive personal pronouns, and also of the negative *ne . . . pas* (*point, plus, jamais,* etc.), when used in connection with them:

1.	2.	3.	4.	5.	6.	7.	8.	9	10.
je	*ne*	*me*	*le*	*lui*	*y*	*en*	*auxiliary verb, or simple tense*	*pas,*	*past participle of compound tense*
tu		*te*	*la*	*leur*				*point,*	
il		*se*	*les*					*plus,*	
elle		*nous*						*&c.*	
nous		*vous*							
vous		*se*							
ils									
elles									

If the sentence is interrogative, the subjects in 1 *come after* 8.

Voici and *voilà* are made up of the imperative *vois,* behold, with *ci* for *ici,* here, and *là,* there. Like verbs, they govern the pronoun in the objective case, and are preceded by it.

Examples: *Où est mon canif? Le voici,* where is my penknife? Here it is; *Où est ma poupée? La voilà,* where is my doll? There it is; *Où sont leurs joujoux? Les voilà,* where are their toys? There they are.

Exercise XV.

1. I am looking (for) (*cherche*) my book and my pens.
2. You have spoken to my brother and sister.
3. He has given a present (*cadeau*) to his friend.
4. He is looking (for) me.
5. She is speaking to you.
6. We have given him a watch (*montre,* f.).
7. He does not speak to them.
8. Has she given them a present?
9. Has he found his watch?
10. I give thee that, he said to me.
11. Give it (m.) to me, said my father to us.
12. Buy (*achète*) thyself an umbrella (*parapluie,* m.).
13. We get up every day at seven o'clock.
14. They never go to bed before eleven o'clock.
15. We give it (m.) to them.
16. She lends it (f.) to you.
17. He has given us some.
18. You have spoken to us about (of) it.
19. If you have any money, give him some.
20. Do not speak to him about it.
21. We do not oppose (*opposer*) it (oppose ourselves to it).
22. If you are looking for your gloves, here they are.
23. You are mistaken.
24. They flatter themselves.

Disjunctive Personal Pronouns. The disjunctive personal pronouns, whether used as subjects or as objects, have but one form. They are:

moi, I, me, to me — *nous,* we, us, to us
toi, thou, thee, to thee — *vous,* you, to you

lui, he, him, to him	*eux* (m.), they, them, to them.
elle, she, her, to her	*elles* (f.), they, them, to them.

The reflexive pronoun *se* also has a disjunctive form, *soi*. Example: *Chacun pour soi*, each one for himself.

2. The disjunctive form is used after prepositions: *nous sommes pour eux et contre lui*, we are for them and against him.

But when a single pronoun is the indirect object (dative), the preposition *à*, to, is not expressed. The pronoun is in the conjunctive form and precedes the verb. If the verb is reflexive, however, the preposition *à* is expressed: *nous nous fions à eux*, we trust to them.

3. When a personal pronoun is used alone, as either subject or object of a verb understood, the disjunctive form is required:

Qui lui a répondu? Moi, who answered him? I; *Qui a-t-il vu? Eux*, whom did he see? Them.

4. When a personal pronoun is the "logical subject" of the verb *être*, preceded by *ce*, the disjunctive form is required:

c'est moi, it is I	*c'est nous*, it is we
c'est toi, it is thou	*c'est vous*, it is you
c'est lui, it is he	*ce sont eux*, it is they (m.)
c'est elle, it is she	*ce sont elles*, it is they (f.)

In this construction the verb is plural when followed by a pronoun in the third person plural.

5. When a verb has several subjects, or several objects, those of them that are pronouns must be in the disjunctive form. In this construction it is usual to introduce an additional pronoun in the conjunctive form, including all the others:

Toi, lui et moi, nous serons ensemble, thou, he and I (we), shall be together.

Il nous verra, toi et moi, he will see (us), you and me.

6. The pronoun coming after *que*, than, as subject or object of a verb understood, must be used in the disjunctive form:

J'y ai été plus souvent que lui, I have been there oftener than he.

Il vous voit plus souvent que moi, he sees you oftener than me.

7. A personal pronoun immediately preceding a relative must be in the disjunctive form:

Moi qui vous parle, je l'ai vu de mes yeux, I who speak to you, I saw it with my own eyes.

8. A pronoun is emphasised by being used once in the disjunctive and again in the conjunctive form:

You work and *I* play, *toi, tu travailles et moi, je joue*.

In this construction the disjunctive pronoun may be placed either before the conjunctive or after the verb:

Tu travailles toi, you work.

9. If the emphasised pronoun is in the third person, and is the subject of a verb, the conjunctive form may be omitted:

Lui pense ainsi, mais eux pensent autrement, *he* thinks thus, *they* think otherwise.

But if the emphasised pronoun be objective, both forms are used:

Je le crois lui, eux je ne les crois pas, I believe *him*, *them* I do not believe.

10. In elliptical sentences, when the only verb expressed is in the infinitive, the pronoun is used in the disjunctive form:

Moi vous trahir, *I* betray you!

11. The disjunctive form is used with a participle to form an "absolute" construction:

Lui mort, nous n'aurons plus de chef, he being dead, we shall no longer have a leader.

12. The disjunctive pronouns form with the preposition *chez* expressions that mean "at my house" or "at home," etc.:

chez moi, at (to) my house
chez toi, at (to) thy house
chez lui, at (to) his house
chez elle, at (to) her house
chez nous, at (to) our house
chez vous, at (to) your house
chez eux, at (to) their (m.) house
chez elles, at (to) their (f.) house

Il n'est pas chez lui, he is not at home.

Nous sommes toujours chez nous le soir, we are always at home in the evening.

Est-il allé chez vous? Did he go to your house?

13. The disjunctive forms, with *même* joined to them by a hyphen, become emphatic personal pronouns:

moi-même, myself	*soi-même*, oneself
toi-même, thyself	*nous-mêmes*, ourselves
lui-même, himself	*vous-mêmes*, yourselves
elle-même, herself	*eux-mêmes* (m.), themselves
elles-mêmes (f.) themselves	

These forms are not reflexive, and may not come immediately after the conjunctive subjects *je*, *tu*, etc.:

Il me l'a dit lui-même, he himself told me.

They may be used in connection with reflexive verbs:

Il s'habille lui-même, he dresses by himself (*lit.*, he himself dresses himself).

14. In French the second person singular and the second person plural are used as forms of address. The singular implies very great familiarity. The use of this familiar form is called *tutoyer*, as:

Nous nous tutoyons, we "thou-thee" each other.

EXERCISE XVI.

1. They are against me and for them.
2. She does not trust him.
3. Whom have you seen? Him.
4. Who answered him? They (m.).
5. Who is there? It is I.
6. We shall go (*irons*) together, thou and I.
7. He has spoken to him and me.
8. We have been there oftener than they.
9. She is more intelligent than he.
10. They, whom we thought (*que nous croyions*) our friends, have betrayed (*trahis*) us.
11. *He* works, but *you* do nothing but (*ne fais que*) play.
12. He say (*dire*) such a thing!

13. They have supplied (*fourni*) the money; he has built (*bâti*) the house.
14. If you do not believe (*croyez*) *me*, will you believe (*croirez*) *him?*
15. That child has written the letter himself.
16. They (f.) have told (*dit*) me themselves that they would come (*viendraient*) this evening.
17. They (m.) are never at home in the evening.
18. Each one for himself and God for all.

KEY TO EXERCISE XIV [PAGE 2110].

Le territoire de la République française est d'environ cinq cent trente-six mille cinq cents kilomètres carrés. Sa superficie est à peu près treize fois la superficie de la Suisse et plus de treize fois la superficie de la Belgique. Sa population est de trente-neuf millions six cent mille habitants. Elle a quatre-vingt-six départements. Son climat est tempéré: sa température moyenne annuelle est de soixante degrés. Sa chute de pluies est de quatre-vingts centimètres. La France forme une république. A la tête du pouvoir exécutif est placé le président de la République. Il est élu pour une période de sept ans. Le service militaire est obligatoire en France dès l'âge de vingt ans. La durée du service est de vingt-cinq ans: deux ans dans l'armée active, onze ans dans la réserve de l'armée active, six ans dans l'armée territoriale et six ans dans la réserve de l'armée territoriale. En temps de paix l'effectif est de cinq cent soixante mille hommes environ. La marine française comprend quatre cent cinquante navires de guerre. Ils sont montés par environ cent mille matelots et soldats de marine. Il y a cinq grands ports militaires. Paris, la capitale de la France, a une population d'environ trois millions. Lyon et Marseille sont aussi deux des plus grandes villes de la France. A Marseille il y a cinq cent cinquante mille six cents habitants; à Lyon il y en a cinq cent vingt-trois mille huit cents. Paris a plus d'un million huit cent mille d'habitants de plus que ces deux villes ensemble. Par ses industries et son commerce Paris est une des premières villes du monde. Marseille est le premier port de toute la Méditerranée et une des dix ou douze places commerciales les plus importantes du globe. Le commerce de la France est très considérable. La valeur moyenne de son commerce extérieur est de douze mille cinq cents millions ou douze milliards et demi: six pour l'importation et six et demi pour l'exportation. La plus longue rivière de la France est la Loire. La longueur de la Loire est de mille vingt kilomètres. Les lignes des chemins de fer de la France ont une longueur totale de quarante-huit mille kilomètres. Les Anglais mesurent les distances par milles, les Français par kilomètres. Le mille anglais est de mille six cent neuf mètres. Les Français indiquent la valeur par francs et centimes. Le franc vaut un peu moins de dix "pence" anglais. Le centime est la centième partie du franc. Il y a des pièces d'argent de cinquante centimes et des pièces d'or de dix francs. La plus grosse pièce d'argent est la pièce de cinq francs. En France les jours de fête sont le premier janvier ou le jour de l'An, Pâques, l'Ascension, la Pentecôte, l'Assomption, la Toussaint, et le jour de Noël. La Toussaint est toujours le premier novembre et Noël le vingt-cinq décembre. Pâques tombe entre le vingt et un mars et le vingt-six avril.

L'Ascension est aussi une fête mobile. Elle tombe quarante jours après Pâques. La Pentecôte tombe dix jours plus tard, c'est-à-dire cinquante jours après Pâques. Les Français célèbrent leur fête nationale le quatorze juillet, en mémoire de la prise de la Bastille en mil sept cent quatre-vingt-neuf.

Continued

GERMAN

Continued from page 2113

By P. G. Konody and Dr. Osten

XXXI. The REFLECTIVE PRONOUNS are used in German to express the reflection of an action on the acting person:

Sing. 1. Ich wasche mir die Hände, I wash my hands [I wash to myself (*dat.*) the hands];
2. du wäschst dir die Hände, thou washest thy hands [thou washest to thyself the hands];
3. er, sie, es wäscht sich die Hände, he, she, it washes his, her, its hands;

Plur. 1. wir waschen uns die Hände, we wash our hands;
2. ihr wascht euch die Hände, you wash your hands;
3. sie waschen sich die Hände, they wash their hands.

Alike in the accusative:

Sing. 1. Ich wasche mich, I wash myself;
2. du wäschst dich, thou washest thyself;
3. er, sie, es wäscht sich, he washes himself, etc.;

Plur. 1. wir waschen uns, we wash ourselves;
2. ihr wascht euch, you wash yourselves;
3. sie waschen sich, they wash themselves.

In the first and second person the personal pronoun [XI.] is used in the required case. Only the third person (*sing.:* er, sie, es; *pl.:* sie) has a separate reflective pronoun—sich—for all genders and numbers, both in the dative and accusative.

The reflective pronouns are employed in all tenses with the verbs of which they reflect the action. The imperative is: *sing.* 2 wasche dir die Hände! (*dat.*); and wasche dich! (*acc.*). Civil address: waschen Sie sich die Hände! and waschen Sie sich!

1. The reflective pronoun immediately follows the finite verb in simple sentences. In the

compound tenses it therefore stands between the finite verb and the constant forms: ich unterhal'te mich, I enjoy myself; and ich habe mich unterhal'ten, I have enjoyed myself; ich werde mich unterhal'ten, I shall enjoy myself; etc.

2. The reciprocity of a reflected action is not expressed by sich, but by einander, each other, one another: sie liebten sich, they loved themselves; and: sie liebten einander, they loved each other.

XXXII. The Cardinal Numerals are:

eins	1	elf	11	dreißig	30
zwei	2	zwölf	12	vierzig	40
drei	3	dreizehn	13	fünfzig	50
vier	4	vierzehn	14	sechzig	60
fünf	5	fünfzehn	15	siebzig	70
sechs	6	sechzehn	16	achtzig	80
sieben	7	siebzehn	17	neunzig	90
acht	8	achtzehn	18	hundert	100
neun	9	neunzehn	19	hundert und eins	
zehn	10	zwanzig	20	101 etc.	

tausend .. .. 1000 eine Million, a million.

After 20 the unit always precedes the multiple of ten, with which it is connected by the conjunction und: einundzwanzig, 21; zweiundzwanzig, 22; etc., corresponding to the English form one and twenty, etc. The numeral eins casts off the s at the beginning and in the middle of a compound numeral, but retains it at the end: einunddreißig, 31; hunderteinundsechzig, 161; but, hundertundeins, 101; etc. Also: es ist ein Uhr, it is one o'clock. But if Uhr (o'clock) is omitted: es ist Eins, it is one [o'clock]. The hundreds, thousands, etc., are formed as in English: zweihundert, 200; fünfhundert, 500; zehntausend, 10,000; hundert tausend, 100,000; fünf hundert tausend, 500,000; etc.

1. (*a*) The numeral ein (*m.*), eine (*f.*), ein (*n.*) takes the declensive inflections of the indefinite article [see V., 4] when preceding the substantive as attributive adjective. It is distinguished from the indefinite article only by the stress laid upon it: er aß nur einen Apfel, he ate only one apple; but, er aß einen Apfel, he ate an apple.

(*b*) If not directly connected with a substantive, it takes the ***strong*** declension of adjectives [see XXVI., 2] with the genitive -es: einer (*nom.*) von den drei Männern, one of the three men; ich sah einen (*acc.*), I saw one; etc. When used substantively it takes a capital letter: Einer sagte es mir, one [person] told it me.

(*c*) With the definite article it takes the inflections of the weak declension of adjectives [see XXVI., 1]: der eine von' den drei Männern, [the] one of the three men. Der Tornis'ter ein-es and des ein-en Soldaten, the knapsack of one soldier, and .... of [the] one of the soldiers. Einer unter euch, one among you; and der ein-e unter euch, etc.

2. The numerals zwei and drei form the genitive with the suffix -er, and the dative with -en, if the case is not easily recognisable by the inflection of some other noun adjunct (definite article, pronoun, adjective, etc.): Er war der Vater zwei-er [or drei-er] (*gen.*) Kinder; he was the father of two [three] children; and er war der Vater zwei [drei] schön-er (*gen.*) Kinder, he was the father of two [three] beautiful children; or, er war der Vater der (*gen.*) zwei Kinder, he was the father of the two children. Er war drei-en (*dat.*) Mädchen ein Vater, and er war den (*dat.*) drei Mädchen ein Vater, he was a father to the three girls. The higher numerals which do not admit these inflections are usually circumscribed with the preposition von, of: er war der Vater von sechs Kindern, etc.

3. The numerals 1—19, if not immediately followed by a substantive sometimes take an -e in the nominative and accusative (zwei-e, drei-e, fünf-e,) neun-e, etc., and -en in the dative: mit (3) vier-en, sechs-en, etc. Both these forms are used in idiomatic expressions, when the number is understood to comprise the substantive: wir waren unser fünf-e, there were five of us [persons]; er fährt mit sechs-en, he drives with six [horses], etc. Those ending in f (fünf, elf zwölf) are pronounced like w; fünfe (pronounced fünwe), etc.

4. The numerals are also used as substantives, with a gender and written with capitals: die (eine) Eins (*f.*) 1; also der Eins-er (*m.*), the one; die Elf (*f.*) 11; das Hundert (*n.*) the hundred; das Tausend (*n.*); die (eine) Million (*f.*), Billion (*f.*); die (eine) Milliarde (*f.*), 1000 millions, etc; also in compounds: das Jahrhundert, the century, etc.; and they take the declension—masculines and neuters strong, genitive with -s, plural with suffix -e or unchanged: des Einser-s, des Hundert-s; *pl.* die Hundert-e, die Tausend-e, die Eins-er; but die Million-en, die Milliarde-n (weak).

XXXIII. The Strong Verbs with the Stem Vowel -i- change it in the imperfect into -a- and in the past participle into -u-, -o-, or -e-. The list of verbs, with their different tenses, given on the next page must be carefully committed to memory.

EXAMINATION PAPER

1. In which person, and for which declensive cases, does the reflective pronoun take a distinct form?
2. Where is the reflective pronoun placed in the normal arrangement of simple sentences?
3. What alterations does the cardinal numeral 1 undergo in German when placed at the beginning, in the middle, and at the end of a compound numeral?
4. Which is the place of the unit in compound numerals above 20?
5. When does the numeral 1 take the inflections of the strong, and when those of the weak declension of adjectives?
6. What are the suffixes for the genitive and dative of the numerals 2 and 3; when are they employed, and in which numerals is the genitive circumscribed by a preposition?
7. Which vowels are taken in the imperfect, and which in the past participle, by the strong verbs with the stem-vowel -i-?
8. Why do some verbs take the prefix ge- in the past participle, whilst others remain without it?

Infinitive		Present Tense Indicative I., II., III., Sing.	Imperfect *Indicative*	Imperfect *Subjunctive*	Imperative Singular	Past Participle
bedingen *	to stipulate, contract	ich beding-e, -ſt, -t	ich bedang	ich bedänge	beding(e)	bedungen
binden	to bind	ich bind-e, -eſt, -et	ich band	ich bände	bind(e)	gebunden
dringen †	to press, penetrate, rush in	ich dring-e, -ſt, -t	ich drang	ich dränge	dring(e)	gedrungen
empfinden	to feel	ich empfind-e, -eſt, -et	ich empfand	ich empfände	empfind(e)	empfunden
finden	to find	ich find-e, eſt, -et	ich fand	ich fände	find(e)	gefunden
gelingen	to succeed	es geling-t (used only in the neuter)	es gelang	es gelänge	es geling(e)	gelungen
klingen	to sound	ich kling-e, -ſt, -t	ich klang	ich klänge	kling(e)	geklungen
ringen	to wrestle	ich ring-e, -ſt, -t	ich rang	ich ränge	ring(e)	gerungen
ſchlingen	to entwine, wind, swallow greedily	ich ſchling-e, -ſt, -t	ich ſchlang	ich ſchlänge	ſchling(e)	geſchlungen
ſchwinden	to vanish, dwindle	ich ſchwind-e, -eſt, -et	ich ſchwand	ich ſchwände	ſchwind(e)	geſchwunden
ſchwingen	to swing	ich ſchwing-e, -ſt, -t	ich ſchwang	ich ſchwänge	ſchwing(e)	geſchwungen
ſingen	to sing	ich ſing-e, -ſt, -t	ich ſang	ich ſänge	ſing(e)	geſungen
ſinken	to sink	ich ſink-e, -ſt, -t	ich ſank	ich ſänke	ſink(e)	geſunken
ſpringen	to leap, jump	ich ſpring-e, -ſt, -t	ich ſprang	ich ſpränge	ſpring(e)	geſprungen
ſtinken	to stink,	ich ſtink-e, -ſt, -t	ich ſtank	ich ſtänke	ſtink(e)	geſtunken
trinken	to drink	ich trink-e, -ſt, -t	ich trank	ich tränke	trink(e)	getrunken
winden	to wind, twist	ich wind-e, -eſt, -et	ich wand	ich wände	wind(e)	gewunden
zwingen	to constrain, force	ich zwing-e, -ſt, -t	ich zwang	ich zwänge	zwing(e)	gezwungen
beginnen ‡	to begin	ich beginn-e, -ſt, -t	ich begann	ich begänne also (begönne)	beginn(e)	begonnen
beſinnen	to consider, deliberate	ich beſinn-e, -ſt, -t	ich beſann	ich beſänne (beſönne)	beſinn(e)	beſonnen
gewinnen	to win	ich gewinn-e, -ſt, -t	ich gewann	ich gewänne (gewönne)	gewinn(e)	gewonnen
rinnen	to flow, run	ich rinn-e, -ſt, -t	ich rann	ich ränne (rönne)	rinn(e)	geronnen
ſchwimmen	to swim	ich ſchwimm-e, -ſt, -t	ich ſchwamm	ich ſchwämme (ſchwömme)	ſchwimm(e)	geſchwommen
ſinnen	to meditate	ich ſinn-e, -ſt, -t	ich ſann	ich ſänne (ſönne)	ſinn(e)	geſonnen
ſpinnen	to spin	ich ſpinn-e, -ſt, -t	ich ſpann	ich ſpänne (ſpönne)	ſpinn(e)	geſponnen
bitten	to ask, beg	ich bitt-e, -eſt, -et	ich bat	ich bäte	bitt(e)	gebeten
beſi'tzen	to possess	ich beſitz-e, -eſt, -t	ich beſaß	ich beſäße	beſitz(e)	beſeſſen
liegen	to lie, to be located	ich lieg-e, -ſt, -t	ich lag	ich läge	lieg(e)	gelegen
ſi'tzen	to sit	ich ſitz-e, -eſt, -t	ich ſaß	ich ſäße	ſitz(e)	geſeſſen

* Dingen, to hire [ich ding-e, -ſt, -t]; imperfect indicative: ich dang, but *better*: *dingte*; subjunctive like imperative: ding(e); past participle: gedungen.

† The verbs with infinitives printed in italics are conjugated with *ſein* (to be), all the others with haben (to have).

‡ Note the subjunctive alternative form with ö.

Note in the above verbs the formation of the past participle with and without the prefix ge-, and consider the reasons for its omission in several cases.

Exercise 1. Insert the missing reflective pronouns:

Ich beei'le . . . . . ; er beeilt' . . . . ; du
I hasten [myself]; he hastens [himself]; thou
liebſt . . . . . . ; wir retten . . . . . . ; ich ſagte
lovest thyself; we save ourselves; I said
. . . . ; Sie ſagten . . . . : ihr ſagtet
to myself; you said to yourself; you said
. . . . ; ſie fürchteten . . . . ;
to yourselves; they feared [themselves];
ich hatte . . . . geſagt; wir hatten . . . . ruinirt;
I had said to myself; we had ruined ourselves;
er würde . . . getötet haben; ſie unterhält' . . . . . ;
he would have killed himself; she enjoys herself;
wir unterhiel'ten . . . . . ; ſchämen Sie . . . . . !
we enjoyed ourselves; be ashamed of yourself!
raſiere . . . . !
shave thyself!

Exercise 2. Insert the missing numerals (fully written) and the declensive inflections.

Ich habe . . . . . Karten; er gab mir . . . . Pfund
I have 21 cards; he gave me £261
für das Jahr . . . .; der Lehrer unterrich'tet
for the year 1901; the teacher instructs
. . . . Knaben und . . . . . . Mädchen, zusammen
42 boys and 57 girls, together
. . . . . . Kinder. Im russisch-japa'nischen Kriege
99 children. In the Russo-Japanese war
wurden . . . . Soldaten verwun'det — . . . .
247,589 soldiers were wounded — 145,437
Russen und . . . . . . Japaner. Wie viel ist . . . .
Russians and 102,152 Japanese. How much is 19
und . . . . . ? . . . . . .; . . . . . und . . . . ? . . . .
and 13? 32; 14 and 9? 23.

Ein . . von euch hat es genommen.
One of you has taken it. —
Ich glaube es war der ein . . von den . . . . Soldaten;
I believe it was [the] one of the five soldiers;
er war der Vater zwei . . . Söhne,
he was the father of two sons, (or with preposition): er war der Vater von . . . . Söhnen

Keys to Exercises in Examination Paper on pages 2112-13

[The exercises being now more advanced, Keys are given in each lesson to the exercises set in the previous Examination Paper.]

Exercise 1 (*a*). Der Griff meines Stockes ist schön; ich gab meinem Freunde deinen Stock; sie brach ihre Uhr; der Deckel ihrer Uhr ist zerbrochen; er fuhr mit seinen und mit ihren Pferden; ich ging zu ihrem Arzte; sie gingen mit ihren Eltern in unseren Garten und bewunderten die Schönheit unserer Blumen. Eu(e)re Freunde und die Brüder eu(e)rer Freunde waren in eu(e)rem Garten und pflückten eu(e)re Blumen.

(*b*). Ihr Freund ist auch der meine (or unsere); er brach nicht blos seine Uhr, sondern auch die deine, die ihre, die uns(e)re, die eu(e)re, die ihre und die Ihre; die Schnelligkeit deines Hengstes ist größer als die des meinen, des seinen, des ihren, des uns(e)ren, des eu(e)ren, des ihren, des Ihren; seine Dogge lief hinter der meinen, der deinen, der ihren, der uns(e)ren, der eu(e)ren, der ihren, der Ihren; mein Pferd schlägt das deine, das seine, das ihre, das eu(e)re, das ihre, das Ihre; deine Freundinnen sind auch die uns(e)ren, die ihren. Die Wolle meines Schirmes ist besser als die Seide des deinen, des seinen, des ihren, des uns(e)ren, des eu(e)ren, des ihren, des Ihren; ich glaube deinem Freunde mehr als dem meinen, dem seinen, dem ihren, dem uns(e)ren, dem eu(e)ren, dem ihren, dem Ihren; er liebt seinen Freund mehr als den meinen, den deinen, den ihren, den uns(e)ren, den eu(e)ren, den ihren, den Ihren, etc.

(*c*). Der Stock ist meiner, deiner, seiner, ihrer, uns(e)rer, eu(e)rer, ihrer, Ihrer; die Dogge ist meine, deine, etc.; das Pferd ist meines, deines, etc.

(*d*). Insert the suffix -ig- between the possessive pronoun and its declensive termination, wherever the pronoun does not precede the substantive.

Exercise 2 (*a*):

ich stehe auf	ich biete an	ich gebe aus
du stehst auf	du bietest an	du gibst aus
er steht auf	er bietet an	er gibt aus
wir stehen auf	wir bieten an	wir geben aus
ihr steht auf	ihr bietet an	ihr gebt aus
sie stehen auf	sie bieten an	sie geben aus
ich schließe bei	ich schlafe ein	ich komme hin
du schließt bei	du schläfst ein	du kommst hin
er schließt bei	er schläft ein	er kommt hin
wir schließen bei	wir schlafen ein	wir kommen hin
ihr schließet bei	ihr schlaft ein	ihr kommt hin
sie schließen bei	sie schlafen ein	sie kommen hin

ich nehme mit	ich falle um
du nimmst mit	du fällst um
er nimmt mit	er fällt um
wir nehmen mit	wir fallen um
ihr nehmt mit	ihr fallt um
sie nehmen mit	sie fallen um

(*b*). Ich verstehe, du verstehst, etc.; ich stehe bei, du stehst bei, etc.; ich verbiete, du verbietest, etc.; ich biete auf, du bietest auf, etc.; ich schließe aus, du schließt aus, etc.; ich beschließe, du beschließt, etc.; ich gefalle, du gefällst, etc.; ich falle auf, du fällst auf, etc.

(*c*). Steh' auf! Stehet auf! Stehen Sie auf! Biete an! Bietet an! Bieten Sie an! Gib aus! Gebet aus! Geben Sie aus! Schließ' bei! Schließet bei! Schließen Sie bei! Schlaf' ein! Schlafet ein! Schlafen Sie ein! Komm' hin! Kommt hin! Kommen Sie hin! Nimm' mit! Nehmet mit! Nehmen Sie mit! Fall um! Fallet um! Fallen Sie um! Versteh! Versteht! Verstehen Sie! Steh' bei! Steht bei! Stehen Sie bei! Verbiet! Verbietet! Verbieten Sie! Biete auf! Bietet auf! Bieten Sie auf! Schließ aus! Schließet aus! Schließen Sie aus! 'Beschließ! Beschließet! Beschließen Sie! Gefalle! Gefallet! Gefallen Sie! Fall' auf! Fallet auf! Fallen Sie auf!

Exercise 3. Der Schüler hat (hatte) gelernt; der Lehrer hat (hatte) das Fenster geöffnet; der Künstler hat (hatte) ein Bild gezeichnet; das Mädchen hat (hatte) gelächelt; der Gärtner hat (hatte) im Garten gearbeitet; das Schiff ist (war) gesegelt; die Kinder haben (hatten) gespielt; die Mädchen sind (waren) errötet; ich habe (hatte) meine Eltern geliebt; er hat (hatte) Unsinn geredet; du hast (hattest) eine Cigarre geraucht; ihr habt (hattet) im Flusse gebadet; sie haben (hatten) die Glocke geläutet; die Kinder haben (hatten) ihr Spielzeug zerstört; er hat (hatte) an der Türe gelauscht; du hast (hattest) den Vater begrüßt.

Exercise 4 (*a*). Die Väter, die Löffel, die Äpfel, die Fenster, die Esel, die Brüder, die Onkel, die Vögel, die Reiter, die Fäden, die Veilchen, die Käse, die Sättel.

(*b*). die Berge, die Hunde, die Jahre, die Kenntnisse, die Hirsche, die Bewandtnisse, die Pferde, die Haare, die Kürbisse, die Labsale, die Abende, die Preise, die Moose, die Fließe, die Schuhe, die Sprosse (also Sprossen) die Geheimnisse.

(*c*). Die Ärzte, die Gänse, die Köpfe, die Bräute, die Hände, die Zähne, die Töpfe, die Fäuste, die Füchse, die Brüste, die Ströme, die Würste, die Krüge.

(*d*). Die Tücher, die Länder, die Kinder, die Gewänder, die Weiber, die Kräuter, die Lieder, die Fässer, die Dörfer, die Glieder, die Würmer, die Gespenster, die Völker.

(*e*). Das Roß, des Rosses, dem Rosse, das Roß, die Rosse, der Rosse, den Rossen, die Rosse; das Los, des Loses, dem Lose, das Los, die Lose, der Lose, den Losen, die Lose; das Hindernis, des Hindernisses, dem Hindernisse, das Hindernis, die Hindernisse, der Hindernisse, den Hindernissen, die Hindernisse.

Continued

Method of Making Straw Shapes. Pressing and Finishing. Net Shapes. Lace and Chiffon Hats. Fancy Shapes for Summer Wear.

STRAW & FANCY HAT SHAPES

THE straw used for working up in hat, toque, or bonnet shapes is at the present time easily obtainable, and can be bought by the yard or the piece of 12 metres (equal to 13 yards). English straws are made in pieces of 12 yards, Italian and some of the expensive makes in pieces of 8 metres. Diagrams **84, 85, 86** show some different kinds of straw. Although made straw hats or bonnets can now be bought at very little cost, they are more likely to fit, be much lighter and more original in design, when they are worked up by hand.

There are several different methods. The one in general use at present by all first-class milliners is to work the straw over a wire shape [see page 1984]. This method is specially suitable for fancy or crinoline straws [**85, 86**], and is the only possible one for making up fancy and more difficult shapes.

Make the wire shape according to the style desired; if for a very fancy crinoline, lace, or a very open straw, cover it with net, chiffon or tulle, and stitch the plait to it. No covering is needed for a non-transparent straw [**84**]. For sewing use glazed cotton to match the straw, and a straw needle.

Pin the straw round the outside edge [**89**], stretching it slightly (if a wide one) along the upper side, making the join where the trimming is likely to hide it. Wirestitch it to the edge wire just below the edge of straw. If the straw is over 1 in. wide, cut it through and interlace the ends, keeping them in place by a few stitches. Some straws can be so joined as to be hardly visible.

When using narrow straw do not cut each round, but continue one into the next.

Notice whether the shape has a curved-up brim like the Napoleon shape or a drooping one like the mushroom. For the first, the plait is sewn on rather tightly, with the right side of straw underneath. The stitches are seen on the wrong side inside the brim.

For drooping brims, the right side of the straw is on the outside of the brim. The stitches will show underneath the brim.

Pin on the second row, and sew it to the first, using the straw stitch, keeping the long stitch on the wrong side, and slanting the little stitch back the way of the plaiting of the straw, which will prevent it being visible on the right side.

Continue pinning and stretching each row along the outer edge, and slightly contracting the inner edge of the previous row till the brim is covered. Hat brims wider in front and sides [**83**] will require gussets—that is, extra rows of straw inserted across the wider parts. Some brims may have three rows of straw at back and five or six along sides and fronts.

For the crown, start from centre of tip, keeping the straw exactly to shape [**88**]. Bind the end of the straw with cotton, turn it under, and sew the straw round and round from the inner edge, manipulating it with the left hand, and easing it sufficiently to allow it to lie flat. In wide straws this is a little troublesome at first, but it is a difficulty which is soon mastered. Each straw is stitched *underneath* the last one, the fancy edge always showing outside. Be careful not to get a fluted tip, which happens when the straw is "eased" too much. If stretched too tightly, the crown will bulge.

If the straw can be pressed, do not sew it to the wire, but make it separately; press it, and then sew it to the crown. Finish off the brim with another edge of straw along the outside edge, and in the case of some toque shapes line the inside brim for two or three rows, or all over. In this case, do not take the stitches through the outside, but slipstitch the straw to the wrong side of brim. The tip must be pressed before the sideband is begun unless it is a dome crown, when it is finished entirely, and afterwards pressed. When the tip is the right size, bend the plait in half; this forms the turnover for sideband; the half-width turned over will be the first row of it [**87**].

Sidebands. For straight sidebands, each row is simply stitched to the next in a straight line. If larger at the top than at the base, tighten each row of the straw towards the headline.

For sidebands larger at the base than at top ease on each row of straw towards the headline.

It is usual to make the crown and brim separately in this method of straw-working. By working the straw over a wire shape as the foundation it can be sewn in all kinds of fancy ways, and two or more different colours of straw used.

The curved-up brims of toques can be trimmed with leaves of straw [**90**], rounds of straw, lace insertion, or lace medallions edged with straw, and various other variations which would not be possible if a wire foundation were not used.

It is possible to work straw without a wire foundation, but this is only suitable for very firm makes [**84**]. Insert a wire the size of headline plus 2 in. (for very brittle straw sew it on), on the top inner edge of straw. Bend it so that the outer edge of plait lies flat on the table, and join as securely and neatly as possible, the wire edge making headline, and the flat edge the row of brim.

Some hat brims are wider in the front than the back, the extra width being obtained by gussets, which should be next sewn on. Mark the centre-front of the headline, keeping the join for centre-back; pin on a piece also with a wire inserted

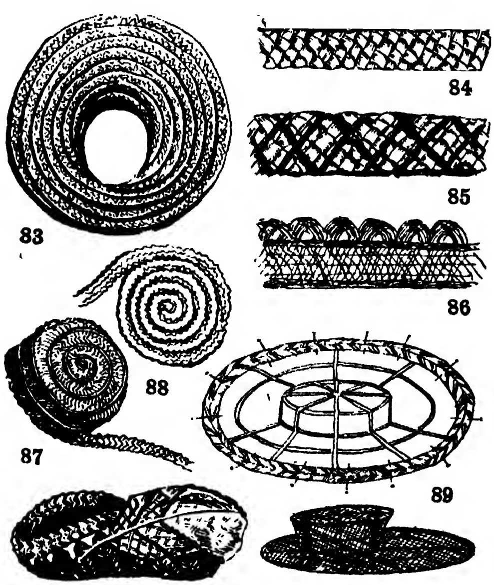
in the inner edge, graduating it to the sides. Repeat till the extra width is obtained. Then insert the wire. keeping it in one length, running it invisibly between the straw edges. Begin from the back, pinning and stitching it on to the gussets till the right size of brim is obtained.

Ease on the straw for fluted and crinkled brims; contract it for turned-up and for drooping brims. For flat brims, ease on the straw just sufficiently to allow each row to lie flat. Make the crown in the same way as before; the wire is not interlaced in the edge of straw unless it be for a very large flat crown, and in a few other exceptional cases.

Straws used to be made up over another hat brim of straw or buckram. If this method is required, pin the straw on to the shape, beginning from the outside edge. The straws may then be sewn together.

Firm, hard straws can be made entirely by hand, starting from the headline, one or two gussets inserted, and hat or toque finished off as explained. It must be wired round the edge. Four support wires laced in and out the straw are then inserted, leaving one end about an inch in hat and the other securely nipped round the outside edge. Finish with a row of straw to cover the edge wire, or line with a gauged chiffon, lace, or velvet lining, finishing the edge with the straw if desired.

Pressing. Only plain straw can be subjected to the process of pressing, as raised fancy edges would be quite flattened and spoiled. At the present time very few straws can be pressed. It is done in this way. Place the brim flat on the table, right side downwards, on an ironing blanket and cloth. Place a damp cloth over it, and press with a warm iron.



83. Straw brim 84, 85, and 86. Three kinds of straw 87. Shaping the sideband 88. The tip 89. Covering wire shape 90. Straw toque 91. Net shape

When nearly dry, remove the cloth, and finish drying it by placing the iron lightly over it. Some plaits are more stiffened than others, so discretion must be used as to the degree of dampness needed. Moisture will make the brim quite stiff and flat. Very limp strands are sometimes brushed over with gum arabic or white of egg.

Curved fancy shaped crowns are best ironed as the work is proceeding, as it is difficult to get the iron in the small curve when the shape is completed. Oval and dipped crowns of the boat-shape type are started with a piece of straw about 2 in. long, and the straw worked round it. Press it as soon as the dip is formed—it is impossible to get the iron in after the crown is finished. [92.]

Bonnets are made on exactly the same principle [94]. The front is worked first, leaving a piece of straw at one ear long enough to finish the back off neatly when the other part of the bonnet is finished. Cut off each straw at the back. The end of the straw left at the ear will finish it neatly. Make the crown separately, and sew it on.

Net Shapes. Hat shapes made in unglazed, French stiff net [91] are used for the foundation of chiffon, silk, linen, broderie anglaise, and mourning millinery. The glazed kind of net is not worth making up, as it loses its stiffness directly, leaving the net limp.

Cut the pattern in the same way as for an espatra shape, with the only difference that ¼-in. turnings are allowed on *all* the parts. Wire in the same manner, sewing the wire inside the turning along the edge of brim, and at the top of sideband. The turnings should be at the bottom of sideband. The ¼-in. turnings of tip come over the top edge of sideband, where they should be secured firmly just under the wire. Large shapes in net hats will require a second round wire, and some supports to keep the brim in shape. The supports are mulled or covered with narrow sarcenet ribbon. As few of these as possible should be used, as the wire is likely to show through the transparent trimmings. Mull all the edges in the same way as for espatra shapes.

Another method much used by good milliners is to make the wire shape and cover it with net cut to shape. Bonnet and toque brims are sometimes made of net, shaped and curved by pleating and easing the net, and afterwards wired.

For a lace hat make the wire shape and cover it with a single or double thickness of tulle or chiffon. Stretch the lace across the brim, with the front on the cross. Pin round headline and edge. Cut the lace round the brim and crown, and allow small turnings. Wirestitch it to the headline and edge wire. Cover the tip in the same way.

Fit the lace round the sideband quite smoothly. Match the pattern, if possible, where the lace has to be joined. Quantity of lace required will be the diameter of the widest part of the brim, plus ½ yd. for large crowns.

If both the upper and under brim are covered

with lace, twice the diameter plus ½ yd. to ⅝ yd. for crown—according to size—will determine the quantity needed. Guipure, and Irish lace look well with the edge of brim bound with velvet or fur; or the upper brim and crown can be trimmed with medallions of lace edged with narrow Valenciennes or ruchings of pleated tulle.

Picture hats are usually large hats of the Gainsborough, Rembrandt, or Amazon type, with tam-o'-shanter, low, high, or jam-pot shaped crowns. They are made of lace, net, tulle, chiffon [93], crinoline, or velvet. All but those to be covered with velvet, which have an espatra foundation, have their foundation shape made of wire, covered with net, chiffon, or tulle. Occasionally the whole shape is covered with tulle quillings. Handsome feathers are their chief trimming, and they are worn with or without tulle strings.

Picture Hats. For chiffon hats make a wire shape, and cover it with one or two thicknesses of chiffon. Mull the edge and bind with velvet or double chiffon. Cut the chiffon into 2½-in. strips on the cross, and join; or use the chiffon double, and run the edges together. Sew the first chiffon fold even with the brim, and let the next rows overlap nearly half-way.

For the sideband, work from headline upwards. Cover the top of crown, starting from the outside edge, and working round and round to the centre.

Lace medallions, or motifs, make a pretty finish, and an écru shade of lace on a black hat relieves what may otherwise be unbecoming.

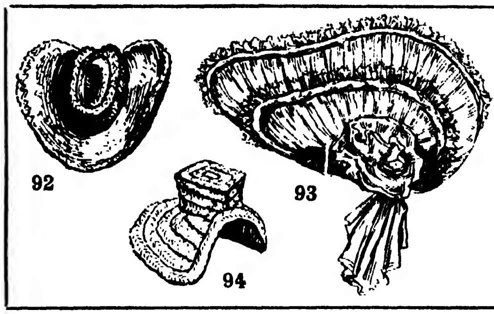
Rows of transparent lace, fancy chenille or crinoline inserted between the folds look well.

For fancy chiffon hats, make a wire shape, and cover it with double chiffon. Cover it plainly with printed or embroidered chiffon of a small simple pattern, such as bunches of pink roses on a white ground. Line the under brim plainly or with gauged chiffon. Edge it with narrow Valenciennes, and sew another row half an inch from edge underneath. Cut out the upper brim again, allowing 1 in. turning. Make a narrow hem round the edge, on which should be sewn narrow black, white, or écru Valenciennes lace.

Make a large round to cover the crown, hem round and edge with narrow Valenciennes lace. Sew in a bandeau. Trim the hat with soft satin ribbon, making a bow at the side, and another on the bandeau. For this hat, ⅞ yd. of double-width printed chiffon, 12 yd. narrow Valenciennes lace, 3½ yd. of 7-in. wide satin ribbon are required.

Motor Hats. For motoring, shapes can be made with a round brim, or a peak in front, of the mushroom shape, with eight-gored crown. Where stiffness is required for the interlining of brim, peak, or band for headline, use firm canvas or double stiff net. Wire as for shape-making. Interline the crown with canvas or quilted linen.

Linen hats are made of double stiff net, cut to shape, and wired round the edge and once in centre brim. Cover top and bottom of brim with linen, tack and machine-stitch round edge once or thrice. Finish crown in the same way and trim plainly with a ruching made of ribbon or crossway silk, or any other simple trimming that may be preferred.



92. Straw boat shape 93. Chiffon hat 94 Straw bonnet

Fancy Shapes. Garden party, river hats, etc., are made of light material and fancifully trimmed. They have a wire foundation covered with two thicknesses of tulle or Brussels net. The edge of the brim is covered with velvet or quillings of lace. The shape may be covered with narrow Valenciennes lace (eased while being sewn on), petals of flowers, medallions of lace, broderie anglaise edged with narrow Valenciennes lace, or net, or tulle quillings. The brim between the medallions may be covered with lace or fine crinoline straw. Ninon silk muslin, accordion-pleated silk may be used, or batiste, edged with lace, baby ribbon, or narrow straw; and there are still an infinite variety of other methods of treatment. These hats must be lightly trimmed.

Drawn silk bonnets may be made of taffetas velours silk, net, chiffon, or chiffon velours. First obtain a pattern shape to work over. Put the support wires on the shape, turning them over the edge to keep them in position. Fix firmly where they cross each other. To cut the material for bonnet, measure length from ear to ear, and allow twice or three times as much for fulness. Then measure width from centre-front of brim to centre of crown, allowing ½ in. extra for each casing. Mark centre-front, and run a casing for outside edge. Decide the position of round wires, and run casings to correspond, measuring distance at centre-front and at ears, also at an intermediate distance if necessary. Push in the wires, making the outside wire long enough to go round the back and wrap over two inches. Pin net or silk on shape, centre-front to centre-front, the silk to reach the ears only. Fix outside wire round back. Draw up each casing in turn to required size, and fix wires to outside wire. Regulate the fulness carefully and secure threads. Nip each support wire in turn over the outside wire; when the last one is thus fixed, the pattern shape will come freely away. Fix the round wires to support wires, and tie them firmly and invisibly wherever they cross. Cut away any superfluous silk in centre of crown, turn it in, and finish the crown off neatly. Bind the back of the bonnet with a piece of silk, velvet, or net, and trim it with velvet, flowers, passementerie, tips, or any light trimming.

Wire Rods and Wire-drawing. Making Pins and Needles. Coiling and Weaving Wire. Wire Ropes and their Manufacture. Wire Netting.

WIRE AND WIRE WORK

The manufacture and working of wire embrace a group of industries the processes in which are seldom described in popular books. This neglect of the wire trades is rather surprising in view of the importance of these trades. The wire-making industry is one of the foundations of our civilisation, and the low cost to which mechanic skill has succeeded in bringing articles of wire enables such articles to be the property of the many. The ordinary pin is turned out at the surprisingly low price of something like one penny per thousand, and each pin has to undergo many operations. The domestic sewing needle is as fine an example of the result of highly developed manufacturing skill as any trade has to offer, and its low price is a surprise to those unfamiliar with its manufacture. Carding wire is an essential in the textile trades, coal and other minerals are raised from the mines by wire ropes, without which the cost of mining would be greatly increased, wire fish-hooks are a necessity to the fishing industry, the modern watch would be impossible without springs of flattened steel wire, wire torpedo nets guard our battleships from hostile attack, and finally wire guns are the weapons of offence used in our Navy and coast defence stations. These few instances of the uses of wire may serve to illustrate its importance to the community, and we may proceed to describe its manufacture and employment.

Iron and Steel Wire. The processes through which the material has to pass before finally emerging as wire demand that good iron and steel should be used for the purpose. Puddled iron and charcoal iron [see page 659] are used. High qualities of wire, including music wire, are made from Swedish iron, which is a special quality of charcoal iron. Steel used in wire manufacture must be free from both phosphorus and sulphur, or the result will be very poor wire. Only steel can be employed in making articles which are to be tempered. From Mr. Bucknall Smith's "Wire: Its Manufacture and Uses" we extract a table showing the average breaking strains of wires made from different classes of iron and steel.

	Tons per sq. in. of Section.
Black or annealed iron wire	25
Bright hard-drawn iron wire	35
Bessemer steel wire	40
Mild Siemens-Martin steel wire	60
High carbon Siemens-Martin steel wire (or "improved")	60
Crucible cast steel improved wire ..	100
"Improved" cast steel "plough" ..	100
Special qualities of tempered and improved cast steel wire may attain ..	150-170

The drawers of wire purchase their material either in the form of billets or of wire rods. In either case they specify quality according to the purpose to which the wire has to be put. If they purchase in billets they must roll them into rods. A "billet" is an ingot of iron or steel usually of somewhat irregular shape in section, but approximating to square and weighing between 80 lb. and 200 lb. These billets are passed, when hot, through rolling mills and emerge as "wire rods." These rods are really coils of wire from 200 ft. to 600 ft. long, the length differing with the size of the original billet and with the diameter to which rolling has reduced it.

Rolling Wire Rods. Productive economy makes it desirable that the rods should be rolled in one heat, as the necessity of reheating when the rolling is partly accomplished adds to the cost materially. Rolling is performed in a series of machines usually called a "train." We may describe them as a number of large mangles with iron rollers provided with grooves around their peripheries. There are two rollers in each machine and both rollers are grooved alike. Some mills have three rollers, but for the sake of lucidity we may discard this consideration. The grooves are not all semicircular in shape. They may be diamond shaped or oval as well. The shape is varied, because the practice "works" the material into a uniform mass, increasing both its tenacity and ductility. The pairs of rollers have grooves which in size are in a descending scale. The red-hot billet passes through the largest grooves—say round—then through rollers with grooves a little smaller—say of diamond shape—then through others still smaller with oval grooves, and so on through the entire series, the shape of the section varying and the size of the section decreasing throughout the cycle. Then, after perhaps ten or twelve different "passes" through rolls, the rod is of the desired diameter, and as it leaves the last pair of rollers it is wound, still hot, on drums which make it into coils. Such in bare outline is the history of the "billet" during its transformation into the coil of thick wire known as a "wire rod."

Various followers of the process described have introduced modifications, chiefly in the direction of automatic mechanisms for handling the rod as it passes from one pair of rollers to another, but the essential principle in all is as we have described it. The rollers, of course, are "live rollers"—that is to say, they are driven by power from an engine, so that they pull through the rod under treatment. Also the rollers have a speed of revolution that increases as their grooves decrease in size. This higher speed is to compensate for the greater length of the rod as it is drawn out by rollers with smaller and smaller grooves. Some rolling mills are arranged so that several rods can be made to pass through at one time, several pairs of grooves being provided on each pair of rollers. This is the highest point in productive economy. After rolling, the rods are cleaned in a tank containing a diluted solution of muriatic or sulphuric acid, are put into lime-water and are finally dried in an oven. They are then ready for the drawing mill.

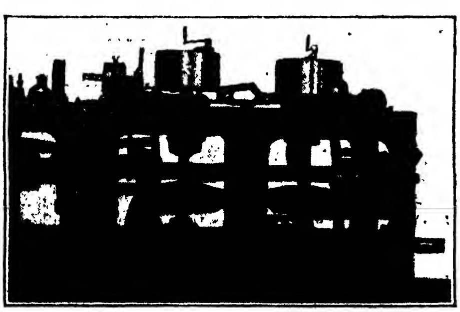
Cold Drawing. The rolling is over and has given us the wire "rods" or coils usually of No. 5 or No. 6 gauge, the former just over and the latter just under one-fifth of an inch in diameter. The

lengths of the rods are from 200 yards to 600 yards long, according to the weight of the billet from which they have been made. The rods were made hot; they are drawn into wire cold. The wire may be one of many shapes—oval, flat, round, square, or U-shaped, according to the shape of the dies through which it is passed. The draw-plate is merely a piece of hard steel with holes of different sizes through which the wire is drawn successively, each hole through which it is taken being smaller than the preceding one. The number of holes through which the wire is drawn depends upon the reduction in diameter required. The finer the wire is to be, the greater is the reduction and the more numerous the passes through the draw-plate. The plates are given to wear, the strain to which they are subject in use being very great, and when the holes have become enlarged by use the plates are heated, hammered, and the holes repunched and made accurate. The end of the thick wire or "rod" is hammered to a point, making an inch or two at the extremity thinner than the body, and able to be put through one of the holes in the draw-plate.

The Drawing Mill. The wire-drawing mill [1] is a bench mounted with a series of "blocks" or pulleys from 12 in. to 30 in. diameter, turning on vertical centres and with a draw plate and pincers to each pulley. The end of the rod, where it has been made thinner in the manner stated, is put through the selected hole in the draw-plate, and placed in the jaws of the pincers, which are attached to a bar. A cam attached to the drum spindle is made to operate, and it pulls or presses the bar and pincers away from the draw-plate, thereby drawing a little of the wire, enough to make a revolution of the drum to which it is made fast. Then the drum itself is put in motion, and the wire is drawn through the die or draw-plate as rapidly as the drum is made to revolve. The speed which can be maintained in working depends upon the amount of attenuation being given and upon the material.

Lubricant. The work of drawing is made more easy by the use of a lubricant. For thick gauges the lubricant is usually of paste consistency—a heavy grease; but for gauges below 20 a thin lubricant such as soapy water is employed. The lubricant not only facilitates the actual work of drawing through the plates, but it also, if wisely chosen, leaves a thin film of grease, which prevents oxidation.

Manufacturers use various lubricants in wire drawing, and each manufacturer is a law to himself in the matter. For fine drawing, a lubricant made of sour beer yeast and olive oil is sometimes used. It is claimed for a mixture of lard and sulphuric acid thinned with water that its use saves a good deal of the annealing otherwise necessary in the various stages of drawing. A hot solution of lime and salt is used by some makers when drawing steel wire. This practice is said to save wear upon the inner surface of the die.



1. WIRE-DRAWING BENCH

Annealing. With the repeated drawing the wire becomes hard, and it is necessary, perhaps several times during the sequence of the drawing operations, to anneal the coils. Wire reduced to a fine gauge may have been annealed about six times during its progress from the wire rod. Some makers, before annealing iron and steel wire, immerse it in a thick cream made with chloride of lime and water. This gives it a protecting coat, which prevents the formation of scale during annealing, and which is afterwards removed by washing in clean water. The annealing ovens are air-tight iron chambers capable of holding from two to three tons of wire coils. They are charged and closed. Then they are heated up to 600° F. or 700° F. The duration of the heat depends upon the gauge of the work in hand and upon the quantity in the chamber. When it is considered that the heat has been maintained long enough, the furnace is allowed to cool slowly. When cool, the wire is withdrawn and "pickled" in acid solution as after rolling, and before the work of drawing proceeds again, another immersion in limewater is given. Then the work goes ahead as before, to return to the annealing chamber should it be necessary. Finally, we have the wire drawn to its final shape, and it is ready for the market or for one of the many industries in which wire is used.

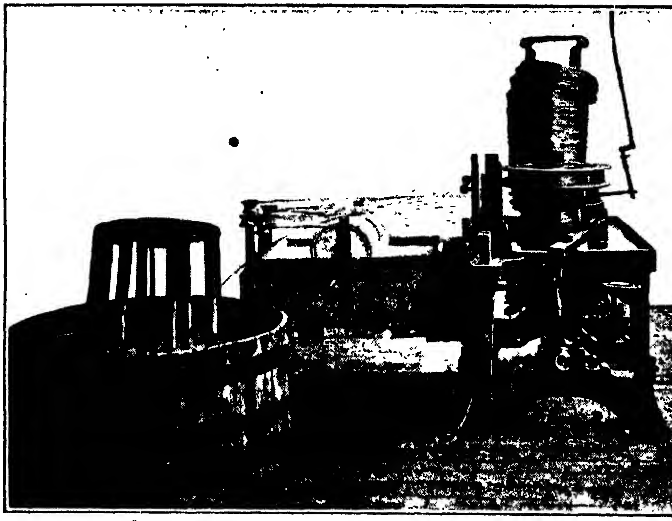
Continuous Drawing. Continuous wire-drawing [2] has come into extensive use during recent years, and is economical. In machines for continuous drawing the wire is not wound on a block, as in ordinary wire-drawing, already described, but is pulled through one die, wound two or three times round a block, then passing through another die, round another block, and so on until the ultimate desired gauge is attained. The circumferential speeds are varied to compensate for the elongation of the wire as it passes through the dies. Metals that require frequent annealing during the process of drawing are limited in the number of dies through which they can pass at one time. Thus, in drawing iron, steel, and brass wire, the saving in working with continuous machines is much less than it is with a metal like copper, which can usually be drawn to its ultimate gauge without annealing.

Our illustration [2] shows the wire reel, which is being drawn down through the several dies, mounted in a tub containing weak acid. This practice is frequently followed, and removes any acid that may have been given to the surface of the wire during the process of annealing. The drawing drums may vary in diameter from 10 in. to 32 in. and may revolve at a circumferential speed of from 300 ft. to 400 ft. per minute. Steel wire, however, must be drawn at a slower speed, to obviate risk of breakage. Soft iron wire and copper wire may be drawn at the rate of 500 ft. per minute, or even more.

Fine Drawing. When, for special purposes, such as watch-springs, fineness and absolute accuracy are demanded, the steel draw-plate is discarded and precious stones, drilled to the required size, are used for the final drawing. The ruby is the usual stone employed, although diamonds and sapphires are also used. A silver wire 170 miles long and ·003 in. diameter has been drawn through a hole in a ruby, and upon micrometer measurement it was found that the size towards the end of the

coil was exactly the same as at the beginning. A hole in a steel plate would have shown signs of appreciable wear with one-tenth of the work. When the ruby or other gem is used, it is mounted in a metal plate, and for flat work, such as the hair-spring of a watch, the hole must be of rectangular aperture.

Wire Gauges. The question of wire gauges is a vexed question, into the details of which we do not intend to enter. For very many years there was no uniformity in the wire gauges, and this led to much confusion and to many mistakes. Every maker almost was a law unto himself, and during the greater part of last century there were over forty different wire gauges used in this country alone. This state of matters was remedied in 1884, when the Board of Trade, after deputations from wire manufacturers and consultations with them, inaugurated and made the legal standard of wire measurement in this country the "Imperial Standard Wire Gauge," which is usually designated by the letters, "S.W.G." Yet some of the discarded gauges still linger in practice, notably the "Birmingham Wire Gauge." We append a table giving the Imperial wire gauge, the Birmingham wire gauge, and the equivalent sizes in decimals of an inch, and in millimetres. The French and German practice is to reckon wire by millimetre sizes.



2. CONTINUOUS WIRE-DRAWING MACHINE
(Bond & Cooper, Birmingham)

IMPERIAL STANDARD AND BIRMINGHAM WIRE GAUGES

Imperial Wire-gauge	Birmingham Wire-gauge	Equivalent Diam. Inches	Equivalent Diam. Millimetres	Imperial Wire-gauge	Birmingham Wire-gauge	Equivalent Diam. Inches	Equivalent Diam. Millimetres
7/0	—	·500	12·699	14	—	·080	2·032
6/0	—	·464	11·785	15	15	·072	1·828
—	0000	·454	11·531	—	16	·065	1·650
5/0	—	·432	10·972	16	—	·064	1·625
—	000	·425	10·794	—	17	·058	1·472
0000	—	·400	10·159	17	—	·056	1·421
—	00	·380	9·651	—	18	·049	1·244
000	—	·372	0·448	18	-	·048	1·218
00	—	·348	8·839	—	19	·042	1·066
—	0	·340	8·635	19	—	·040	1·016
0	—	·324	8·229	20	—	·036	·9140
1	1	·300	7·620	—	20	·035	·8886
—	2	·284	7·213	21	21	·032	·8124
2	—	·276	7·010	—	22	·030	·7617
—	3	·259	6·578	22	—	·028	·7109
3	—	·252	6·400	—	23	·025	·6347
—	4	·238	6·045	23	—	·024	·6093
4	—	·232	5·892	24	24	·022	·5585
—	5	·220	5·588	25	25	·020	·5078
5	—	·212	5·384	26	26	·018	·4570
—	6	·203	5·156	27	27	·016	·4062
6	—	·192	4·876	28	28	·014	·3555
—	7	·180	4·571	29	29	·013	·3300
7	—	·176	4·470	30	30	·012	·3046
—	8	·165	4·191	31	—	·011	·2800
8	—	·160	4·064	32	—	·0108	·2743
—	9	·148	3·759	33	31	·010	·2539
9	—	·144	3·657	34	32	·009	·2300
—	10	·134	3·403	35	33	·008	·2031
10	—	·128	3·251	36	34	·007	·1777
—	11	·120	3·047	37	—	·0068	·1727
11	—	·116	2·946	38	—	·006	·1523
—	12	·109	2·768	39	35	·005	·1269
12	—	·104	2·641	40	—	·0048	·1219
—	13	·095	2·412	41	—	·0044	·1118
13	—	·092	2·336	42	36	·004	·1015
—	14	·083	2·108				

Drawing Properties of Various Metals. The drawing qualities of metals are due to their ductility and tenacity. Ductility is the capacity of changing molecular form, and tenacity is the power of resisting separation. When these qualities are high and are combined in a metal, that metal possesses excellent drawing properties. Most metals are capable of being drawn into wire, although some—as, for instance, antimony—are brittle and useless for want of tenacity. Gold is the most ductile of the ordinary metals, and it is followed by silver, platinum, iron, copper, zinc, tin, and lead in the order named. Steel, again, is the most tenacious of the metals, and is followed by iron, copper, platinum, silver, gold, zinc, tin, and lead in the respective order.

Metals are sometimes drawn in combination. Steel wire of large gauge, after cleaning in a solution of sulphuric or muriatic acid, may be given a coating of copper by immersion in a solution of sulphate of copper. If the copper-coated wire be then put through the draw-plate, it may be drawn very fine, the copper remaining unbroken, but attenuated. Silver-gilt wire is made in the same way. The coating of gold upon a silver bar or rod may be less than one-thousandth part of the latter, but drawing this out to hair thickness still leaves an unbroken coating of gold upon the cheaper metal.

Telegraph Wire. Both iron and steel wire are used for telegraph purposes. For lengthy spans, and where great tensile strength is necessary, steel wire is preferred, but wire made from Swedish charcoal iron is used for ordinary work. The wire is generally galvanised [see Galvani-ing.] The qualities demanded in wire for telegraph purposes are ductility in a high degree and freedom from flaws and impurities. Phosphorus and manganese impair electrical conductivity, hence wire for telegraph purposes should be free from these impurities. It is considered, however, that carbon and silicon have no influence upon electrical conductivity. Government departments and railway companies have rigid specifications stipulating the size, weight, electrical resistance, the minimum number of twists in the strand, and specific tests for strength

and ductility of wire to be used for telegraph purposes.

For covered telegraph and telephone work, a wire of silicon bronze is much used. This alloy is found to be very high in electrical conductivity. Here are two analyses of such wire:

Telephone Wire.			Telegraph Wire.		
Copper	..	99·94 per cent.	Copper	..	97·12 per cent.
Tin ..	..	·03 ,,	Tin ..	..	1·14 ,,
Silicon	..	·02 ,,	Silicon	..	·05 ,,
Iron	..	trace	Zinc ..	..	1·62 ,,
			Iron ..	..	trace

Fencing Wire. Both plain and strand wi[re] are largely used for fencing, the latter having pr[e]ference in this country. Where large tracts have to be enclosed and cheapness is a consideration, cheap iron or steel wire (usually No. 8 S.W.G.) black varnished is used. A coil contains between 500 and 600 yards, and weighs 1 cwt. Fencing of strand wire is usually galvanised.

Barb Wire. Barb wire for fencing owes its origin to America. It might with justice be called "barbarous" wire. It no doubt fills a practical purpose in times of both peace and war, and the quantity manufactured is very great. It is usually galvanised after having been made.

Two wires, generally of 12 or 14 standard wire gauge, are twisted together, and the barbs (short pieces cut obliquely at both ends and wrapped twice round the main strand with their ends projecting) may be "open-set"—that is, be about 6 in. apart, or "thick-set"—that is, be from 3 in. to 4 in. apart. It may be "two-point," or "four-point," which mean that the barbs may be single, presenting two points only, or they may be set double when there are four points of danger for the unwary every few inches. Barb wire contains from 335 lb. to 440 lb. to the mile.

There are a few other varieties of barb wire; in one, a strip of serrated hoop iron is enclosed in the strand, and in another a plain single-strand wire of oval section has its edges cut obliquely, the spikes made thereby being raised so as to offer offence to the intruder; but the pattern to which we have already made reference is made in overwhelming proportion.

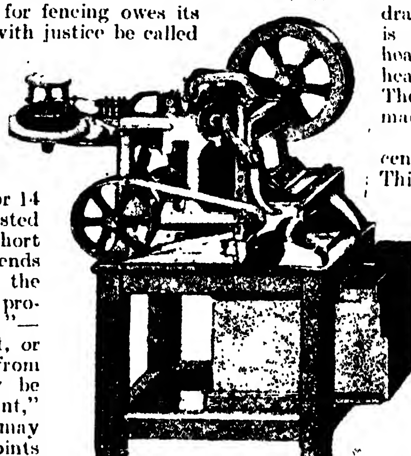
Piano Wire. The piano manufacturing trade is a large consumer of steel wire. The great and constant strain to which steel wire is subject when strung in a piano demands a quality of wire capable of resisting this tensile strain without breaking and without elongation. The total tension upon the wires of a grand piano approaches 20 tons. The strain upon one wire in a piano is as great as if the writer, or the reader—unless he be abnormally heavy—were suspended from it. The carbon in steel used for piano wire ranges, according to Mr. Bucknall Smith in special tests made by him upon samples from various makers, from ·570 per cent. to ·740 per cent.; silicon from ·032 per cent. to ·205 per cent.; sulphur up to ·017 per cent.; phosphorus from ·004 per cent. to ·018 per cent., and manganese from ·120 per cent. to ·425 per cent. Physical properties of the wires tested were as follows in three samples upon which experiments were made.

Diameters.	·040 in.	·036 in.	0·37 in.
Torsion or turns in 6 in. ..	60 to 70	30 to 40	60 to 70
Ultimate tensile strength	400 lb.	318 lb.	340 lb.
Equivalent tension per inch of section	142 tons	140 tons	141 tons

The music wire gauge differs from the "Imperial standard" (S.W.G.) wire gauge. It is as follows:

Music Wire Gauge.	12	13	14	15	16	17	18	19		
Diameters in Inches	029	·031	·033	·035	·037	·039	·041	·043	·045	·0
Nearest size in Imperial Wire Gauge	22	21	21	20	20	19	19	19		

Steel piano wire must be hardened, and this is usually done before the wire goes through the last drawing operation. The procedure is as follows: The wire is first heated in the ordinary way to red heat, and then allowed to cool. Then it is placed in a metal bath made of 40 per cent. lead, 12 per cent. 26 per cent. antimony, 21 per cent. tin, and 1 per cent. bismuth. This metal bath is heated above melting point, and the wire must remain in it until it has attained the same temperature as the metal, which, of course, is longer with thick wire than with thin wire. It is then taken out, and water is sprinkled over it. This process has discoloured it, and by giving it one more drawing, it is made bright again. If it need not be bright, then the hardening may be done after the last drawing.



3. PIN-MAKING MACHINE
(Kirby, Beard & Co., Ltd., Birmingham)

There are other purposes for which wires of exceptional strength are required—notably for cranes, marine hawsers, mining, and bridges. We have seen a weight of 1 ton suspended from a steel wire of No. 8 gauge, to be used for deep-sea sounding.

Gold and Silver Wire. Gold wire is now seldom used. Its place is taken by silver-gilt wire. The gold is put on to the silver rod in the form of leaf, a piece of which 4½ in. square weighs about 18 grains. The gilded rod is then drawn out through steel dies, and, as it gets down to the finer gauges, through dies made from gems—diamonds, rubies, or sapphires. The amount of gold put on the silver rod is about 2 per cent. of the less precious metal, yet even this small proportion can be drawn out to extreme fineness. Twenty-four grains of gold in a silver wire have been drawn out to the length of 410 miles. The silver-gilt wire used for embroideries, laces, vestments, and uniforms generally contains from 1,500 to 2,500 yards to the ounce. Sometimes the so-called silver-gilt wire is really copper silver-gilt. A rod of silver, before gilding, is drilled and a rod of copper inserted. Then the gold is applied to the surface of the silver as already mentioned, and the three metals are drawn together, the attenuation

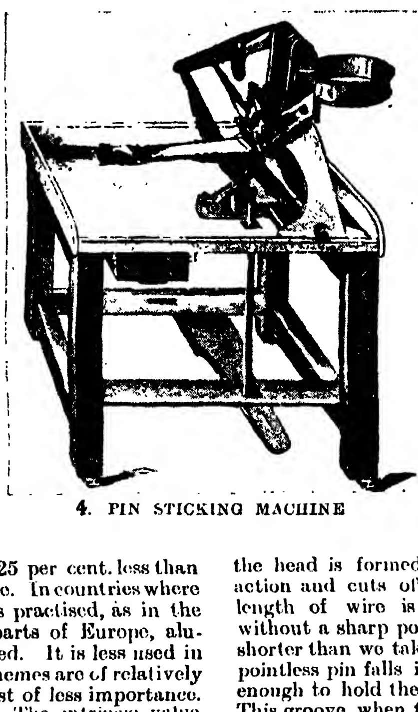
during the process being uniform, and illustrating the remarkable ductility of all three metals.

Brass and Copper Wire. The quality of brass wire depends upon the proportions of the constituent metals of which the brass is composed. A high proportion of zinc gives a light colour and a brittle and springy wire. For fine gauges of wire, and for weaving into gauze such as is used extensively in paper-making, a brass high in copper is used.

The old method of making brass and copper wire, and that still in extensive use, is to roll the metal cold between flat rolls until the thickness desired—depending upon the final gauge of the wire—is attained. This operation yields strips, which are then cut into thin rods, to be afterwards drawn into wire through draw-plates or dies on a wire-drawing bench, or through a continuous wire-drawing machine in the manner described for iron and steel wire.

Aluminium Wire. Aluminium in its pure state has a restricted use in the form of wire. It is light, but its tensile strength is low, being only about 10 tons per square inch of cross section. Its elastic limit is also low, a further factor which militates against its use. Fine aluminium wire is sometimes used for scientific instruments when lightness is required, and is used in embroideries instead of silver wire. Aluminium bronze, however, an alloy of aluminium and copper, yields a metal high in tensile and elastic properties being also a good conductor of heat and electricity, and inoxidisable. Hence wire of aluminium bronze has a wider sphere of usefulness than wire of pure aluminium.

Aluminium wire is used to some extent in electrical engineering. Regarded with disfavour at first by electrical engineers, it is winning its way because of the saving in first cost by comparison with copper. The initial cost is about 25 per cent. less than that of an equivalent copper line. In countries where long overhead transmission is practised, as in the United States, Canada, and parts of Europe, aluminium is being largely adopted. It is less used in England, because overhead schemes are of relatively small extent, and saving of cost of less importance.



4. PIN STICKING MACHINE

Wire of Rare Metals. The intrinsic value of platinum is very high, hence its use as wire is very limited. It can be drawn into very fine wire. It is employed in the manufacture of electrical apparatus and scientific instruments where the ability to resist oxidation, acids, and high temperatures is required. It cannot, however be used for electric glow lamps, as it fuses too readily. Osmium and tantalum are, however, rare metals which have recently been introduced into the manufacture of filaments for electric glow lamps. Their use, especially the latter variety, will probably extend. Special measures have to be adopted to reduce osmium to the form of wire.

Pins. Pin manufacture is an important British industry, the chief seat of which is Birmingham, where indeed are made about three-fourths of the quantity produced in the country. It is computed that 50,000,000 pins are manufactured every day, and the statement constitutes a comment upon human carelessness in small things. Pins are made from wire the size of the shank or body of the pin, and the wire is almost always of brass. The material must be soft enough to allow the head to be upset from the stem, and hard enough to serve its ultimate purpose without bending too easily. The brass from which pins are made by the best makers contains from 60 to 65 per cent. of copper, 35 to 40 per cent. of zinc, traces of lead and of iron, never aggregating more than ·5 per cent., and occasionally minute traces of tin, these last being impurities. For long years the standard composition for pin brass was two of copper to one of zinc, and indeed this mixture came to be generally known as "pin brass," but the slight saving achieved by reducing the copper percentage has caused that practice to be followed.

The brass ingot is usually about 2½ in. square, and is hot-rolled to about ⅜ in. diameter, as already described. Cold rolling is sometimes practised, but it requires a brass richer in copper, and is therefore more expensive. In either case the wire is drawn to its final size through draw-plates.

Pinmaking. The illustration [3] on the preceding page will help to an understanding of the actual process of pinmaking. The coil of wire is placed on the revolving drum as shown. The end is led through a guide hole, and then between iron pegs, which straighten it and guide it to the machine. A sliding plier arrangement seizes the end of the wire, draws it forward, and pushes it through a hole in a small iron plate. Here a tiny hammer or punch "upsets" or thickens the end of the wire, thereby forming the pin head. The machine has been set carefully to the gauge of the length of pin required, and as soon as the head is formed a shearing blade comes into action and cuts off a short length of wire. This length of wire is a rough pin with a head, but without a sharp point. In a space of time infinitely shorter than we take to describe the movement the pointless pin falls into an inclined groove just wide enough to hold the pins suspended by their heads. This groove, when the machine is in operation, contains a row of pins suspended. A revolving cylinder with file teeth graduated from coarse at the entering end to fine at the finishing end operates upon the end of the suspended pins, which move backwards and forwards in the groove, and files the ends to sharp points. The short wires, perfect in form but far from perfect in finish, then fall from the lower end of the groove into a receptacle. The machine we have seen has turned out the pins at the rate of from 180 to 220 per minute.

Finishing Pins. The pins are still yellow brass. They must be whitened, or "silvered." But they are greasy, and must first be cleaned They may be revolved or "tumbled" in barrels or cylinders with a solution of caustic soda. This cleans off all adhering grease. Then they are transferred to "kettles," or vessels heated by steam.

Metallic tin in fine powder is spread over them, some hot solution of bi-tartrate of potash is added, and the vessels are sealed up. The pins are allowed to boil for about four hours, when they emerge silvery and bright in their coating of tin. Then they go to revolving barrels or drums containing sawdust, and are tumbled about until they are dry and polished. The operator now handles them upon a tray. He agitates this tray, and thereby expels any dust which may adhere to them. Then they go to the final machine [4], final as far as the manufactory is concerned, and are put into rows, and issue as papers of pins. The machine that performs this operation is almost as ingenious as the machine that made the pins. The pins are placed in a sort of hopper, and the girl operator sweeps them with a brush into grooves that lead down to the rolls or strips of paper into which they are to be put. The machine creases the paper into the ridges required, and the operation of a lever causes the paper to come up to the rows of pin points, which are then pushed into their respective places in the paper. The papers are made to contain 100 to 500 pins.

Needles. The public are given to associate needle manufacture with pin manufacture, and if they have thought about the subject at all, imagine that the processes of manufacture are somewhat similar. This idea is a mistaken one; the processes are quite dissimilar. The manufacture of needles is a finer operation, and demands greater skill as it is not so dependent upon automatic machinery. Needles are made from a superior quality of cast-steel wire. This wire is delivered to the needlemaker in coils. A workman cuts this wire into short lengths, each length sufficient for two needles. These short wires are not perfectly straight, but have to be made so before anything else is to be done with them. The wires are taken in bundles about as big as can be compassed with the two hands, and an iron ring is placed at each end of the thick bundle. The bundles are heated in a stove, and then placed upon an iron table, where the workman rolls them backwards and forwards, still in the bundle, pressing a curved bar called a "rubbing knife" upon the body of the wires between the rings. This operation, which requires skill, makes the wires quite straight and regular by one wire rubbing against another under the pressure given.

Making Points and Eyes. Pointing is the next process. It is effected in an automatic machine, in which the mechanism holds the wires and presses them against a swiftly revolving grindstone, which forms the points and makes the needles ready for the eye-stamping machine. The process of pointing needles used to be fraught with very great danger to the health of the workmen, few of whom were able to work at their trade beyond the age of forty; but for the last two decades conditions have improved, and suction fans are made to carry the steel-dust and sand from the grindstone out of danger of inhalation by the workmen.

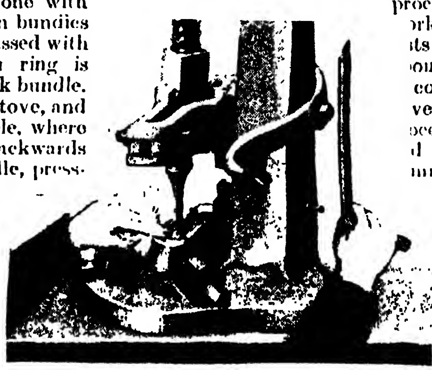
5. STAMPING NEEDLE

The stamp [5] is like a small drop forge, operated by a stirrup pedal. Taking in his left hand a bundle of wires, the stamper places them in rapid succession upon the lower die of his machine, and with his foot causes the upper die to descend with force. The dies form the heads, make beneath the needle-eye the short grooves that act as guides in the act of threading, and also almost pierce the eye itself. As many as 6,000 wires per hour can be handled by a skilled man. The needles are still twins, every wire being two needles, attached by their heads.

The press where the *eyeing* is done has a die similar to that of the stamping machine, but made so as to pierce the eye quite through. One by one, the double needles are placed upon the bed of the press [6], and the handle causes the die to come down. The holes are made, and as the tool retreats again the twin needles show a tendency to stick to it, but a special part of the mechanism pulls the wires from the die, which ascends to repeat the operation.

The stamp has left the head of the needle rough. Girls thread the needles upon a fine wire, and the result is what look like fine combs. The filer takes the "combs" in hand, and with his file, or with a flat grindstone, clears away the "rag," or burr, from both sides of the head. Now each wire is placed in a hand vice, and is parted in the middle—the operation of stamping having made the parting easy—and another treatment with the file makes the head smooth where the pairs have been joined.

Hardening and Tempering. The needles now go into an oven or stove, usually heated by gas, and are raised to red heat. They are then cooled by being plunged into oil, after which they are hard and brittle as glass, and quite useless as needles. They have been *hardened*. The tempering process, performed by the same ...rkman who hardened them, con...ts in heating the needles up to ...out 600° F., and allowing them ... cool gradually. Any needles that ...ve become crooked during the ...ocess of hardening must be taken ...d straightened with a small ...mmer on an anvil, one by one.



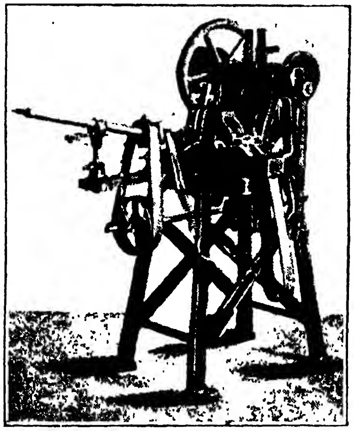
6. THE EYEING PRESS

The heads of the needles are softened by heat, and then follows the process of scouring and burnishing. The former alone takes about a week. Its object is to remove the dark coating of protoxide of iron which the needles have taken on as a result of the operations described, and to show a surface of polished steel. The needles are placed upon canvas strips laid in wooden troughs, and have poured upon them a mixture of oil, powdered quartz, and soft soap. The canvas strips are closed both at the sides and ends, and the sacks of needles are placed upon what is called the "runner bench," a table with boarded sides. A heavy wooden block works backwards and forwards on the bags, turning the needles and pressing them one against another in the gritty composition. Several times during the day, when the operation is going on, the needles are opened out and inspected, and finer grit

supplied. Finally, for the last scouring, what is known as "polishing putty" is put in. The needles are then taken out, boiled clean, and dried thoroughly in warm sawdust.

Finishing Touches. The needles must now be sorted out, for all these processes have made them of varied lengths. They are placed, with heads all one way, upon a narrow board in a row about one inch deep, and the long ones are removed by hand.

A drill is then passed through the eye of each needle, to make certain that there is no roughness that would fray the thread as the needle was being used. Then the finishing-room does its part to the all but perfect needles. Cylinders covered with leather buffs, upon which a polishing composition is put, burnish the needles. The workman handles each needle separately. The points are then ground a little, for the cycle of operations has blunted them slightly. An operator holds them against a stone mill for this purpose. Then the needles are rubbed between two pieces of buff leather to remove any moisture or stains. Finally, they are taken into hot store-rooms for some time, as a last precaution, and then they are made up into the familiar packets which we see on the market. This brief review of the processes of needle manufacture will make it hard to understand how the needlewoman can purchase needles for the small price at which any haberdasher or draper will be pleased to supply them.



7. TACK AND TINGLE MAKING MACHINE
(Bond & Cooper, Birmingham)

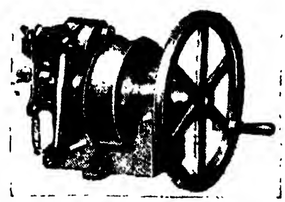
Wire Nails. The manufacture ot wire nails is an enormous industry, which is, however, chiefly in the hands of German firms, who command the greater part of the world's trade in common varieties of wire nails. The functions of the wire nail machine is similar to that of the pinmaking machine, which we have already examined, although there is no great similarity between the two. Wire nail manufacture is a much simpler process than pinmaking. In the former case there are no elaborate pointing, polishing, and finishing operations to be gone through. The wire is fed into a machine in the coil, and is automatically straightened, cut into lengths suitable for the nails being made, pointed, and headed. The operations of cutting and pointing are performed at the same time. The end of the wire, as it enters the machine, is gripped by dies, cutters part it into suitable lengths, and the flat head is put on by a percussive or a pressing part of the mechanism. There are two types of machines, one of which makes the head by successive blows, and the other by pressure. The latter machine [7] is the better and the more generally used. Its output is much larger than that of the percussive machine. The output of a machine is from 100 to 300 nails per minute, according to size, and with mechanical means of yielding such an enormous output it is not surprising that the old-time nailer is extinct as a craftsman. Clout nails and wrought shoe nails and hobs, none of which are, however, made from wire, are the only articles in the category of nails which are still made by hand.

Wire nails range from 1 in. up to 6 in., and many thicknesses are made in every size. Almost all the wire nails used or manufactured in this country are made of round or oval wire, the proportions being about 5 per cent. of oval wire nails, or *brads*, used for door panels and other purposes, and the remaining 95 per cent. being round wire nails with the checkered heads. The oval wire nails have usually a *clasp* head, which is narrow, and owes its strength to its height instead of to its size in either direction laterally. The purpose of this form of head is to enable it to be sunk into the door-panel moulding, so as not to be visible in the finished door. In some countries square wire nails are the most acceptable variety. Obviously, any section of wire nail desired can be made by feeding the machine with suitable wire, and any shape of head can be given by equipping the machine with suitable heading dies. Small brass and iron nails for shoes are made in the manner described, but the sizes of such nails run from $\frac{3}{8}$ in. to 1 in. long.

Fig. 7 shows a machine used for this smaller class of work. Its particular purpose is for wire tacks and tingles.

Wire Coiling. There are numerous purposes for which wire coils are used. Fig. 8 illustrates a machine for either hand or power use. The wire coil may be seen issuing from the coiling gauge. The machine is simple in its use, and rapid in its output. More complicated machines make upholsterers' springs, which are made of steel wire coated with brass or copper, usually the latter. Such machines are automatic, making each spring narrow in the waist, as required, and cutting it off when finished.

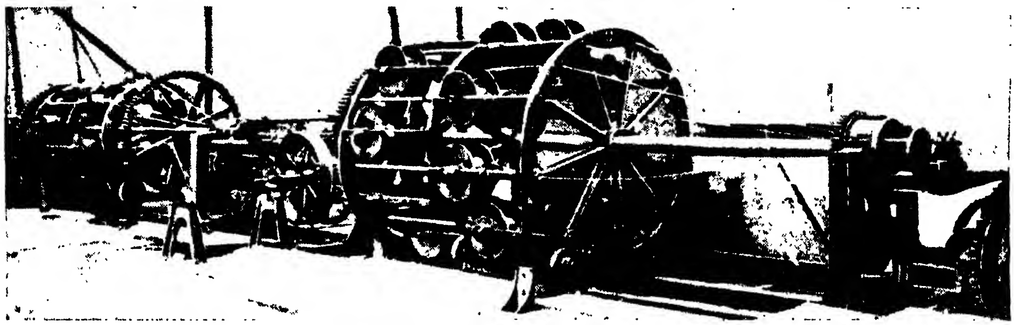
Wire Ropes and Cables. Wire ropes are divided into three classes: "laid ropes," "formed ropes" and "cable laid ropes," and there are important differences between them. The first has a central core of hemp or soft wire surrounded by six strands, each containing a similar central core. A formed rope, again, has a greater number of wires in its composition. Around the six wires forming the strand as used in the laid rope are placed another layer of wires, or, perhaps, more than one; otherwise there is no difference. A cable laid rope is now used for all diameters, and is made by stranding six laid ropes together to form one rope.



8. WIRE-COILING MACHINE
(Sir James Farmer & Sons, Salford)

Flexible Ropes. Wire ropes, or cables, are often required to be more flexible than is possible with only wire strands. Such ropes are necessary for marine purposes. The usual practice is to make a wire rope around a hempen core. Sometimes each individual strand of the rope has a core of hemp. The making of such composite ropes presents no difficulties if the working of the ordinary stranding machines be understood. The saving of both bulk and weight by the use of wire

cables is very great. According to Lloyd's regulations a hempen rope of 13 in. circumference and a wire hawser of 4½ in. are considered of equal strength. The former weighs 40 lb. per fathom and the latter only 15 lb. Wire ropes for marine purposes are generally made of galvanised wire, and have usually hempen cores.



9. WIRE-ROPE MAKING MACHINE
From a photograph by Messrs. W. N. Brunton & Son, Musselburgh

Manufacturing Wire Rope. The manufacture of wire ropes and cables represents the largest and most important use to which wire is applied, and its use is ever increasing with the growing demand for all kinds of metallic ropes and cables. The last twenty years have seen the introduction of many improvements in the construction of the machinery employed in the manufacture of wire ropes and cables. These improvements are the outcome of the ever-growing demand for better, stronger, heavier, longer, and more diversified wire ropes and cables. For many purposes, a great demand has sprung up for wire ropes and cables composed of a large number of fine wires, so as to render them more flexible, and to obtain the greatest possible certainty concerning their quality.

Many very heavy cables are being used in connection with mines, bridges, ropeways, and similar work, and these can be made only on very large machines; such machinery can make cables weighing up to 80 tons each in one length—that is to say, in the case of an 8-strand cable weighing 80 tons, each strand has to weigh ten tons, and the cabling machine carries 8-strand reels.

Considerable variety has been introduced into the manufacture of cables by the use of wire of irregular section, and machinery has been modified to facilitate the use of irregular-shaped wires. Generally speaking also, many improvements have been made so as to facilitate the employment of high speed in the running of cable machinery. At the present time, stranding and cabling machines are running about 50 per cent. quicker than formerly.

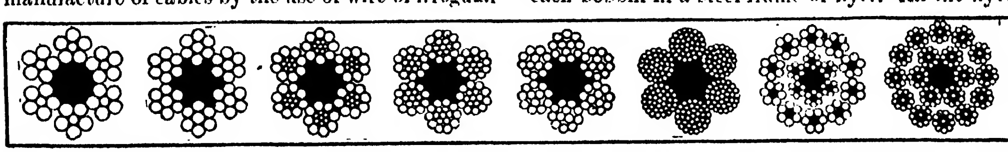
Wire Winding. The first operation is the winding of the wires on to the bobbins of the machines. This has to be done with care and regularity, so that the bobbins may contain their full capacity of wire, and also to ensure that the wires run freely from the bobbins. Wire-winding machines are made to wind simultaneously on to six bobbins if the bobbins are small, say of 5 in. to 8 in. diameter; if they are large, each winding machine is constructed to wind one bobbin.

Recent improvements have been introduced into the construction of these machines to make them automatic in action, so that whereas formerly one skilled man was required to attend to two machines, now one unskilled man can attend to seven machines.

Fig. 11 represents an improved wire-winding machine. During the passage of the wire from the reel to the bobbin it is not only kept constantly tight, but also in constant contact with a horizontal guide or traverse-pulley, furnished with a groove. This effects a regular winding on of the wire, with the result that on each bobbin the maximum quantity of wire is wound, and in the most regular manner possible. The traverse motion can easily be regulated in order to adapt it to the thickness of the wire to be wound, and to the width between the flanges of the bobbin. A further important advantage results through the wire being treated with the greatest care in its passage from the ring to the spool. The traversing-pulley revolves in the same direction as the wire and runs at the same speed, so as to avoid all scraping or scratching, which is damaging in the case of galvanised or tinned wire.

Strand Forming. The next operation is forming the wire strands, some of which are made with a hemp core, and some without core. All the bobbins containing the wires to be used in making the strand are placed in the wire-stranding machine, each bobbin in a steel frame or flyer. All the flyers are fixed in iron rings, which revolve round a central tube through which the core passes. If the strand is to be constructed of 19 wires, the stranding machine must carry 18 bobbins. The wires are drawn from the bobbins with the utmost regularity, and, passing through dies, they assume their proper position, and form the desired strand.

Stranding machines of the most modern construction must be able to make strands composed of a maximum number of wires, and be able to revolve at the maximum speed. The best means of attaining this is by combining several machines together, and by keeping their diameter as small as possible.



10. SECTIONS OF WIRE ROPES SHOWING VARIOUS FORMS USED FOR MINE HAULAGE AND WINDING
By courtesy of Messrs. W. N. Brunton & Son, Musselburgh

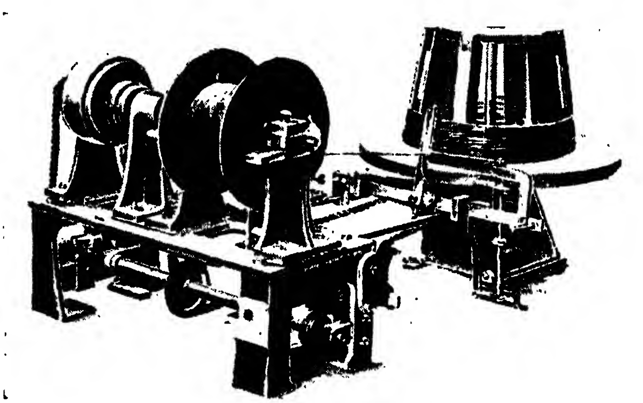
Combined Stranding Machines. A growing demand exists for combined wire stranding machines, capable of running at high speeds and making strands composed of a large number of wires. The principal reason for this is that ropes and electric cables possessing, among other special qualities, much greater flexibility than formerly, are in ever increasing demand. These machines possess several important advantages, which we set forth by taking as an example a treble stranding machine composed of three sections to carry 6, 12, and 18 bobbins respectively.

Each combined treble stranding machine is capable of being transformed into three separate and independent stranding machines in such a manner that each section can work in either direction, make its own strand, and wind it on its own reel. Thus:

Section "A" can make a strand of 7 wires.
Section "B" can make a strand of 13 wires.
Section "C" can make a strand of 19 wires.

Each section can run at the full rate of the speed of which a machine of its size is capable.

The sections can be run semi-independently. Sections "A" and "B" can be run together to make 19-wire strand, while section "C" is simultaneously making a 19-wire strand; or sections "B" and "C" can be run together, making strand up to 31 wires, while section "A" is making a 7-wire strand. When all the three sections of the machine are combined, they can be run in either direction, and produce strands up to 37 wires, at the speed of section "C." The three sections, when combined, are able to make the strand by forming a core, say of 7 wires, putting round it a layer of 12 wires, and putting round it another layer of 18 wires. The three sections, when combined, are able to form a strand by carrying all the wires to the front lay-plate, and there combining them simultaneously into one strand of 37 wires.



11. WIRE-WINDING MACHINE

These combined machines are not merely several machines placed one after the other, but are specially designed for the manufacture of multi-wire strands. If stranding machines of ordinary construction are placed one behind the other, the length of the combined machine is enormous. To avoid this, each section is furnished with its own draw drum, and, alongside it, its own winding-on apparatus, so that when each section is working as a separate machine, the three strands produced simultaneously are taken upwards, each passes round its grooved swinging pulley, then descends, and each one is wound on to its reels. Some machines are employed to make strands up to 61 wires by using a wire core of 7 wires, and are composed of:

Section "A" carrying 12 bobbins.
Section "B" carrying 18 bobbins.
Section "C" carrying 24 bobbins.

For telephone cables, combined machines are made to carry up to 224 pairs of wires.

Wire Cabling. Wire cable machines are made both of vertical and horizontal construction. The former are constructed each with six, eight, or nine flyers to carry the strand bobbins, and, in addition, each machine has one central flyer to carry the core bobbin. The bobbins vary very much in size, and may contain each from 2 tons to 10 tons of strand.

Several important improvements have been made in these machines. For instance, the whole body of each machine, instead of revolving on one central step, now revolves on a series of steel balls, placed in special steel circular paths. This arrangement reduces very materially the power required for driving the machines, and does away with the annoyance and frequent stoppages arising from heating and wearing of the central step in the old style of machines. Each closing machine is furnished with an improved double-geared winding-on apparatus, working automatically with self-acting traversing motion for winding the finished rope or cable on to the reel.

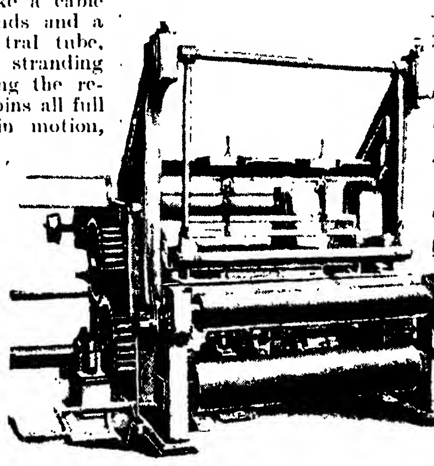
The horizontal wire rope and cable machines are constructed to carry from six to 12 steel flyers and bobbins. The body of such a machine is mounted on a powerful steel tube revolving in long bearings; the core passes through this tube; a stand is supplied for the back of each machine to carry the core bobbin. The rings of the body mounted on the tube run on anti-friction rollers, which are easily regulated, support the body and facilitate the running. The flyers carrying the bobbins are made of steel. The bobbins vary very much in size, say from a 5-cwt. to a 60-cwt. capacity. Each machine has a suitable winding-on apparatus, with reel, indicator, etc. To ensure the maximum speed, the cast-iron body rings are hooped with wrought-iron hoops, shrunk on hot, as a security against the danger of accidents.

A Compound Wire-cable Machine. Here are particulars of a typical modern compound wire-cable machine such as that shown in 9. It carries 42 bobbins of wire, up to No. 11 gauge, and makes in one operation a 7-strand cable, 3 in. in circumference and without any splice, whatever may be the length and weight required.

The driving is communicated from a headstock, by means of spur gearing, to a hollow central steel tube, 17 ft. 6 in. long, 6 in. external diameter, with hole through 2 in. diameter; this steel shaft runs the entire length of the machine to the lay-plate, and carries the whole of the stranding mechanism, and is made hollow to allow of the central core for the cable passing along the inside. By means of a sun and planet motion, the centre wheel of which is fixed to the steel tube, motion is conveyed to six bobbins, which carry the six central wires for the six strands, and these bobbins are carried by themselves on a separate ring. Then follow three other rings also placed on the central tube; between the

first and second rings revolve three stranding apparata, and between the second and third rings three other stranding apparata, all these six stranding apparata being driven by means of spur gearing fixed to the central steel tube, and motions are introduced for lengthening and shortening the lay of the wires in the strands. The six strands pass through dies so as to ensure perfect rotundity, thence over guide rollers and through the head of the machine.

After passing through the lay-plate, the six strands enter a set of dies, in the centre of which passes the core, and are thus formed into a cable. These dies can be set nearer to or farther from the lay-plate, according to the diameter of the cable being made. The finished cable passes five or six times round a draw drum 5 ft. in diameter, which is driven by gearing. An ingenious arrangement is attached to the delivery end of the machine, which, working by friction on the edge of the cable as it is being delivered, automatically records the exact length as it is being made. The operation of the machine will be understood from the above description, but it may be interesting to add that, assuming it is intended to make a cable composed of six strands and a central core, the c tral tube, which carries the six stranding apparata, each carrying the required number of bobbins all full of wire, being set in motion, causes the six wire strands to issue from the six stranding apparata and to combine together. In their centre is placed the core of manilla, or hemp rope, which, having been previously saturated with tar oil, passes along the middle of the central tube and takes its place exactly in the centre, where the six strands combine around it, and thus form the cable.



12. WIRE-WEAVING MACHINE
(Sir James Farmer & Sons, Salford)

Uses of Wire Ropes. The industrial uses of wire ropes are always extending. At the top of the tree are enormous wire cables for suspension bridges. Messrs. Richard Johnson & Nephew, Limited, of Manchester, recently made for a suspension bridge at Cincinnati, United States of America, two wire cables, each a mile long and each containing 52,000 wires from end to end. The total weight of the two is 500 tons and the breaking strain is 6,500 tons. Incidentally it is a source of national pride that an English company can compete successfully for such articles in a high-tariff wire-manufacturing country like the United States.

Ropes for winding purposes find their chief sphere for use in mines [see MINING].

Certain cautions must be observed in the use of ropes for hoisting purposes. A steel rope is not so flexible as a hempen cable and the strength is seriously impaired if the pulleys over which the ropes run are of too small a diameter. Such ropes also should never be made to coil in more than one direction, as is sometimes done. To cause a wire rope to coil in two directions, one opposite to the other, is to subject it to an undesirable strain and to shorten the life of its efficiency by one-half. Ropes for hoisting purposes should be freely lubricated when in use.

Winding ropes for use in mines are usually about 4 in. in circumference, and the drums or pulleys upon which they run have usually a diameter of from 20 ft. to 30 ft.

Wire Netting. The trade in wire netting is very large. Yet it is little more than half a century old. In the 'forties of last century wire netting began to be made by cumbrous hand process, to describe which would have only a historical interest. It is with the wire-netting machine first invented by Mr. Barnard, of Norwich, in 1855, that we have concern. The wire generally used for netting is common annealed iron or mild steel wire. Wire-netting machines may differ in detail, but the principles of most are similar. They are invariably adaptable to make many widths of netting and many different meshes. The limits of width are from 1 ft. to 6 ft., and even up to 9 ft. may be purchased. The meshes obtainable run from ½ in. up to 4 in., the larger sizes being usually called "sheep" netting. The most common meshes are from 1½ in. to 2 in. The wire used i 20 and 22 gauge for ½ in. n p tc from 10 to 16 gauge for 4 h. In this country the standard r l of netting is 50 ft. long.

The us l wire-netting machine consists e ntially of a number of tubes witl i each of which a tight coil of wire is wound, always by a special hine for the purpose. These tubes, which contain the so-called "helices" of tightly-coiled wire, have at their top ends semicircular pinions. Another series of wires is fed to the machine from bobbins, and are led through tubes also fitted with semicircular pinions. By a peculiar half turn and sliding motion, these tubes "waltz" about as the wire is pulled through the machine and rolled upon a cylinder. Suitable apparatus control the size of the mesh and the strand that forms the selvedge border.

Wire Cloth or Gauze. Wire woven into fabric is used in many industries. The paper-making trade uses large quantities, the gold-mining industry has need of wire gauze of special quality, and flour millers make demands upon the wire-weaver. Wire may be woven so fine that 40,000 meshes go to the square inch. This degree of fineness can be better appreciated by an illustration. The half-tone photographic blocks used as illustrations in this article have a surface made up of minute points. There are 14,400 of these points in every square inch, but the wire cloth mentioned above has almost three times as many holes as the half-tone block has points.

This degree of fineness is, however, unusual. The machine commonly employed for weaving wire [12] can produce a mesh of from two to 100 holes to the lineal inch—that is, of from four to 1,000 holes to the square inch. It is really a loom driven by power and is entirely automatic in action.

Hotel Books. Visitors' Ledger. Gas Company's Rental Ledger. Bankruptcy. Statement of Affairs. Deficiency Account. Compositions. Proofs of Debt.

TABULAR BOOKS AND BANKRUPTCY

THE student has already been introduced to the subject of tabular bookkeeping, although it has not hitherto been referred to by that name. Specimens of books kept on the tabular system were given in the petty cash book on page 276, the three-column cash book on page 536, and the columnar purchases book shown in the previous article. The leading principle which those books were designed to illustrate is that items of a similar nature are capable of classification in the books of first entry, and that such classification has the effect of shortening the work of making the final entries in the ledgers of the concern. The principle is capable of considerable expansion in many directions in various businesses and institutions.

Tabular Cash Book. Dealing with the cash book first, it may be pointed out that this is the most important book in such institutions as charities and hospitals where, if a suitable form of cash book is prepared and the book carefully kept, there is frequently no need for any further financial record, as it is a simple matter to prepare a summary of the cash book at any time, showing the position of the institution. As no trading is carried on, no profit and loss account is necessary, the principal account required by, and submitted to, the board of management being an account of receipts and payments, with a statement of outstanding liabilities to date. The latter can easily be prepared from the file of unpaid accounts, and if that is kept up to date the combined cash summary and liabilities statement should be all that is required.

The reason that the tabular system is so suitable for these institutions is that all their receipts and payments fall under a few well-defined heads. For instance, the receipts of a hospital consist of subscriptions, donations, patients' payments, legacies, and income from investments and properties. Many of them also receive grants from King Edward's Hospital Fund and from the Hospital Sunday and Saturday Funds. The receipts side of the cash book might therefore be ruled with columns providing for each of these classes of income, further columns being added for items of miscellaneous receipts and for the total. The payments will consist of the salaries and wages of the medical, nursing, and clerical staff, rent, rates and taxes, tradesmen's accounts, drugs and appliances, repairs, and miscellaneous expenses. Columns would be provided for each head of expenditure and for the total.

Advantage of Classification. In the case of the large London hospitals, such a book as this would, of course, not be sufficient to record all the financial transactions; but even in their cases, such a cash book is of the utmost value in curtailing the clerical work, inasmuch as it classifies the items, and enables the postings to the general ledger to be made in total monthly. The accounts to which the receipts are posted are not, of course, the personal accounts of the donors, subscribers, etc., but nominal accounts for subscriptions, donations, or as the case may be.

In trading concerns, besides the three usual columns for discount, cash, and bank, it is very useful to have on the debit side a column for recording all receipts in respect of cash sales; and on the credit side, a similar column for cash purchases, as the necessity for posting such items in detail to the purchases and sales accounts is thereby obviated, all that is required being that the totals of the columns should be posted at the end of each week or other suitable period. Further, in dealing with the system of self-balancing ledgers, we saw that unless separate cash books were kept for each ledger, columns were necessary on each side of the cash book to record receipts and payments relating to accounts in the respective ledgers. The student, therefore, perhaps unconsciously, has gradually been becoming acquainted with the tabular system in relation to the cash book. A form of tabular purchases and sales book was shown and explained in detail in the previous article, and need not consequently be further dealt with now.

Tabular Ledgers. This brings us to the subject of tabular ledgers, the method of using which may not at once be apparent to the reader. Probably the greatest use of such a ledger in trading concerns is made in hotels where, in large establishments, there would be thousands of personal accounts in the course of a year. The charges to visitors consist of items of the same kind day after day, and it would manifestly be impracticable to have ledger accounts for the visitors on the usual lines, debiting them daily, and crediting the various accounts of the articles supplied, such as apartments, provisions, wines, etc. The staff required to keep books on such principles in a large hotel would be almost equal to that required to run the concern, and would not even then be such as to satisfy the requirements of the proprietor. To meet this difficulty, a form of book has been devised known as *the Visitors' Ledger*, which saves a considerable amount of labour, and yet gives all the information required for the general accounts of the business. An abridged form of such a ledger is shown on the next page. The entries in it are made either direct from slips supplied by waiters and other servants of the hotel, showing the charges to be made against each visitor, or from a day book in which the slips have first been recorded.

MONDAY, 1st JULY, 1905

No. of Room.	Name.	Hotel.						Sustenation.						Stock.				Totals for Day.	Balance Brought Forward.	Grand Totals.	Amounts Paid.	Discounts and Allowances.	Accounts Carried to Ledger.	Balance Carried Forward.	No.
		Apartments.	Attendance.	Fires and Light.	Baths.	Laundry.	Paid Out.	Breakfasts.	Luncheons.	Dinners.	Teas and Coffee.	Suppers.	Servants' Board.	Wines.	Spirits.	Beer and Minerals.	Cigars.								
1	T. White ..	15 0	2 0		1 6	2 0		2 0	2 6	3 6				3 0			1 6	1 13 0	2 4 6	3 17 6				3 17 6	1
2	F. Black ..	5 0	2 0		1 0		1 6	1 6	2 6	3 6					1 6	6		19 0	1 3 0	2 2 0	2 2 0				2
3	W. Green ..	5 0	2 0	6				2 0		4 6	1 6		8 0	5 0				1 8 6		1 8 6				1 8 6	3
4	G. Grey ..	10 0	2 0		1 0			2 6	3 0			4 0		4 6			2 0	1 9 0		1 9 0				1 9 0	4
5	S. Brown ..	7 6	2 0		1 6	4 0		2 0	2 6									19 6	3 6 6	4 6 0	4 5 0	1 0			5
6	J. Pink ..	5 0	1 0							3 6				2 6			1 0	13 0		13 0				13 0	6
7	W. Scarlett	7 6	2 0		1 0				3 0			3 6		3 0	1 0	6		1 1 6		1 1 6				1 1 6	7
8	B. Gold ..	8 0	1 0					2 0										11 0	3 1 0	3 12 0			3 12 0		8
	Total ..	3 3 0	14 0	6	6 0	6 0	1 6	12 0	13 6	15 0	1 6	7 6	8 0	18 0	2 6	1 0	4 6	8 14 6	9 15 0	18 9 6	6 7 0	1 0	3 12 0	8 9 6	

The entries in this ledger require little further explanation than they furnish in themselves. A page of the book, or more, if necessary, is set apart for each day. The charges against each visitor are entered in the manner already mentioned, and cross-cast into the daily total column. Any amount brought forward from the previous day is added, and the total entered in the grand total column. If the visitor pays his account, the amount is entered in the column provided for the purpose, and the account thereby closed. If he does not pay, the amount is entered in the carried forward column, and will appear on the page for the following day in the brought forward column. Any overcharge or other allowance to which the visitor may be entitled, is entered in the appropriate column, and should any visitor leave without paying his account, or if, for any reason, any amount is left unpaid after a visitor has given up his room, the balance due from him is carried into an ordinary ledger, where an account is opened in his name, on which he is debited with the amount he owes.

Connection with General Books. The totals of the first sixteen money columns are entered daily in a summary ruled with corresponding columns, and at the end of a month a journal entry is made debiting *Visitors' Account* in the general ledger with the grand total, and crediting the various nominal accounts with their respective totals for the month. The visitors' account would then be credited with the cash received, and allowances made, and the balance of the account would represent the sum then due from visitors, and should correspond with the amount carried forward in the visitors' ledger on the last day of the month.

Before the totals are entered in the summary daily, care must, of course, be taken that the cross-cast agrees with the sum of the daily total column; any discrepancy must be rectified before the transfer is made. The daily total, plus the amount brought forward, must agree with the grand totals column, which, in turn, must equal the sum of the last four columns in the ledger. The "amounts paid" column should be carefully checked with the "visitors' cash" column on the debit side of the general cash book.

Visitors' Accounts. The accounts rendered to visitors are prepared on the same principle as the ledger, the only difference being that the form is ruled to cover a week. Columns are provided for each day, and for the total, while the different items of charge are shown one under the other instead of as headings of columns. The great advantage of rendering bills on this system is that they can be compiled day by day, and will be ready at any time a visitor calls for his account upon leaving.

The tabular ledger we have been considering owes its form largely to the necessity of carefully analysing the debits to the visitors, in order to ascertain the revenue under the different heads over which the income of an hotel business is

spread. But there is another class of undertaking in which tabular ledgers are not less valuable, where the income is derived from practically only one source, but where there are many debtors with whom transactions take place only at regular intervals and then at some distance of time. Examples of such undertakings are gas, water, and electric light companies. This form of ledger is suitable also for the rate-collecting department of municipal authorities, and for the rent-collecting department of a large estate. The form reproduced on this page is ruled in a manner specially suitable for a gas company, but it will be apparent to the reader that it is capable of being adapted to the requirements of any of the businesses mentioned, and, indeed, to many others.

NEW STREET

Name and No. in Street.		Gas Consumed Quarter to Lady Day.	Rate per 1,000 Feet.	Amount.	Meter. No.	Meter. Rent.	Stove. No.	Stove. Rent.	Arrears.	Total Amount Due.	Paid. C.B. fo.	Paid. Amount.	Bad Debts.	Arrears Forward.	Like Particulars for Midsummer Quarter.	Do. for Michaelmas.	Do. for Christmas.
1	W. Smith	15,600	2/6	1 19 0	657	2 0			2 1 0	4 2 0	68	4 2 0					

This form practically speaks for itself, and very few words are necessary to elucidate it. The amounts due for gas consumed are obtained from the books of the men employed as meter readers, who make a quarterly inspection of the meters for the purpose of obtaining the particulars. The meter and other rents follow a fixed scale. Any charges other than those of a standing character, are not dealt with in this ledger, but are treated separately, and applications for amounts due for fittings, connections, etc., will be dealt with by another department.

Bad Debts Ledger. Any debts regarded as bad, although entered in the column for that purpose, are not thereby abandoned or neglected. The accounts are closed so far as this particular ledger is concerned, but they are transferred to a *Bad Debts Ledger*, which is also kept in a tabular form, and gives brief particulars of the nature, amount, and age of the debt. It is convenient in many businesses to keep such a ledger, for while a trader does not wish to encumber his ordinary ledger with accounts which may be regarded as dead—although there are balances due on them—he does not wish to lose sight of them. They are, therefore, transferred to a book which is largely in the nature of a register, in which only one line is devoted to each. They are thus in a form capable of easy supervision, and although not regarded as assets from the accounts point of view, they may, with careful nursing, result in something being recovered.

Petitions in Bankruptcy. The law of bankruptcy, as it exists today under the Bankruptcy Acts of 1883, 1890, and 1913, works, and is intended, as much for the protection of the debtor as of the creditor. The term bankrupt is generally applied rather loosely to any person in a state of commercial insolvency; but, strictly, it should be used only in reference to a person who has been adjudicated bankrupt by the Court. This statement necessitates an explanation of the steps which must be taken before the stage of adjudication can be arrived at.

The first step in bankruptcy proceedings is the presenting of a petition to the Court by a creditor or creditors for at least £50, asking that an order, known as a *Receiving Order* be made against a debtor. Every petition must be based upon what is known as an act of bankruptcy. There are several of these, and they consist of acts indicating either insolvency or an intention on the part of the debtor to defeat or delay his creditors by more or less fraudulent means. The act of bankruptcy upon which the majority of petitions are presented is known as failure to comply with the terms of a bankruptcy notice. This is a notice served upon a debtor by a creditor who has obtained judgment, requiring payment or security to the satisfaction of the creditor within seven days. If the terms of the notice are not complied with the debtor has committed an act of bankruptcy upon which a petition can be founded. Bankruptcy business is dealt with by a particular division of the High Court, and also by certain of the County Courts, and upon presentation of a petition a day is appointed to hear it. If the court is satisfied that it is equitable that a receiving order should be made it directs accordingly.

The immediate effect of a receiving order is that possession of the debtor's property is taken by an officer of the Board of Trade, known as the Official Receiver, and it becomes the duty of the debtor to lodge within seven days a statement of his affairs.

Statement of Affairs. The statement must be in a form prescribed by the Board of Trade in accordance with the Bankruptcy Acts, and it is in connection with this statement that we are now principally concerned. Several schedules are provided in which have to be entered (1) the different classes of creditors in three groups, (*a*) those

holding no security, (*b*) those holding security to the full amount of their claims, (*c*) those holding security for less than their claims; (2) liabilities of the debtor on bills which he has received from customers and others and subsequently discounted, and upon which he is, therefore, contingently liable as endorser; (3) other contingent liabilities; (4) claims of the landlord for rent, which he can recover by distress; (5) claims for rates, taxes, wages, etc., by creditors who are given a special priority over others against the general assets not specifically charged to secured creditors.

A form is also provided in which the debtor has to set out fully the whole of his property apart from book debts, for which a special sheet is provided. A separate form is also supplied for any bills of exchange which he has on hand available as assets. When these forms have been completed they are summarised on a sheet in the following form, this sheet being known as the *Front Sheet:*

that some creditors, being given by law a special priority or preference, are entitled to payment in full before the ordinary creditors receive anything. The amount of their claim is, therefore, deducted from the total of the assets and the balance is the amount available for the ordinary creditors.

From the nature of the necessity for the preparation of the statement of affairs it is unlikely that the assets will exceed the liabilities, and there is, therefore, generally a deficiency of assets to meet the claims of the creditors. Even when a surplus is shown on a statement it is nearly always illusory and arrived at by the extravagant valuation of assets.

Deficiency Account. When a deficiency is shown it has to be explained in a further sheet, known as the *Deficiency Account*. It is required that this shall cover at least a year before the receiving order and begin, where possible, at a time when the debtor has a surplus of assets over liabilities. The object

STATEMENT OF AFFAIRS OF G. BLACK ON 30TH JUNE, 1906

Gross Liabilities	Liabilities (as stated and estimated by the debtor).		Expected to Rank.	Assets (as stated and estimated by the debtor).	Estimated to Produce.
865	Unsecured creditors as per List A		865	Property as per List H, viz.:	
250	Creditors fully secured as per List B ..	250		Cash at bankers	8
	Estimated value of security	300		Do. in hand	15
				Stock-in-trade (cost £500) ..	250
	Surplus carried to contra	£50		Furniture	50
187	Creditor partly secured as per List C	187		Life Policies	—
	Estimated value of security	150	37	Other Property, viz.:	
				Shares in copper mine .	10
56	Liability on bill discounted other than debtor's own acceptances (List D)	56		Book Debts (List I): Good	75
	Not expected to rank against assets	—		Doubtful 123; Bad 200 — 323 ..	
200	Contingent or other liabilities (List E)	200		Estimated to produce ..	50
	Of which it is expected will rank against the estate for dividend		100	Bills of Exchange on hand (List J)	25
25	Creditor for rent recoverable by distress (List F)	25		Surplus from securities as per contra	50
33	Creditors for rates, taxes, and wages (List G) payable in full	33			533
	Deducted contra	58		Deduct Creditors for rent, rates, etc. . ..	58
					475
				Deficiency explained in Statement K	527
1,616			£1,002		£1,002

Front Sheet. It will be observed that this statement resembles in some degree an ordinary balance-sheet, in that it is intended to show the assets and liabilities of the debtor. A balance-sheet of a going concern is, however, prepared upon the assumption that there is no immediate necessity for the realisation of the property, which can therefore be stated at its value to the proprietor from the view of utility. The property of the debtor, on the other hand, is valued upon the basis of early realisation; it may be as a going concern, but is probably at break-up prices. It will further be noticed

of the deficiency account is to show how that surplus has disappeared, and how the deficiency shown on the front sheet has arisen. The account, therefore, is largely in the nature of a profit and loss account and is made up in the form as shown on next page.

The complete statement of affairs has to be verified on oath by the debtor and lodged with the Official Receiver, who calls a meeting of the creditors to decide the course to be taken in dealing with the estate. They may decide to wind it up in bankruptcy, and apply to the Court to adjudge the debtor a bankrupt. If they take this course a trustee may be

appointed at the meeting who will, after certain formalities, take over the assets from the Official Receiver and proceed to realise them for the benefit of the creditors. When they are fully realised, he distributes the proceeds amongst the creditors pro rata. after first paying his own remuneration and the costs and expenses of the bankruptcy proceedings. The distribution of a bankrupt's assets amongst his creditors is called a dividend.

Public Examination and Discharge. After the meeting of creditors, the debtor has to attend for his public examination, which consists of an appearance in open court, when he is questioned by the Official Receiver, the trustee, and any creditors who may so desire as to his past dealings with his property. After the public examination has been concluded the debtor may apply for his discharge from his bankruptcy. This application is heard in open court, and notice of the hearing is sent to all the creditors. At the hearing the Official Receiver reports the result of his investigations into the debtor's conduct and affairs, and the trustee and creditors may then be heard against the application. by the Official Receiver after the debtor's public examination has been concluded. The Official Receiver reports upon the scheme or proposal, and if the Court is satisfied it is for the benefit of the creditors, the arrangement is sanctioned, and the debtor thereby relieved from the various disabilities of bankruptcy.

Reference has been made to creditors who have proved their debts. This relates to the manner in which creditors are required to lodge their claims in bankruptcy proceedings. When the Official Receiver issues notices for the meeting of creditors he sends out also what is known as a form of *proof of debt*. This is a skeleton form of affidavit which has to be completed and sworn by the creditor. It states that the debtor was, at the date of the receiving order, and then is, indebted to the person on whose behalf the proof is lodged in the sum named therein, and for the consideration stated. Any security held by the creditor has to be fully stated in the proof and valued. In order that the valuation made by the creditor shall be a fair one, the Official Receiver or trustee has the right in certain circumstances to call upon the creditor to deliver the security to him upon being paid the amount of the valuation. When no trustee is appointed at the meeting, the Official Receiver acts in that capacity.

DEFICIENCY ACCOUNT

Excess of Assets over Liabilities on 1st July, 1905	1,000	Net loss on trading from 1st July, 1905, as per books of business ..	221
Deficiency as per Statement of affairs	527	Bad debts as per schedule	273
		Expenses incurred since 1st July, 1905, other than trade expenses, viz., household expenses of self and wife	360
		Other Losses and Expenses :	
		Copper mine shares	40
		Loss on bills discounted	100
		Losses by Stock Exchange speculations	533
	£1,527		£1,527

If the Official Receiver reports that the debtor has been guilty of certain offences the Court will either refuse the discharge or suspend it for not less than two years. The principal offences which will entail this consequence are inability to pay 10s. in the £, trading with knowledge of insolvency, speculation, failure to keep proper business books, fraud, and previous bankruptcy. If the discharge is granted the debtor is relieved from all liability for debts incurred prior to the receiving order but for one or two unimportant exceptions. A bankrupt who has not obtained his discharge is not allowed to contract a debt of £20 without disclosing the fact that he is an undischarged bankrupt. If he should do so he renders himself liable to imprisonment.

Compositions. To go back a short distance, it should be mentioned that the debtor sometimes brings forward at the meeting of creditors a scheme of arrangement or a proposition to pay a composition of not less than 7s. 6d. in the £ in consideration of being discharged from his liabilities. If the proposal is approved by a majority in number representing three-fourths in value of the creditors who have proved their debts, it is brought before the Court

Trustee's Accounts and Release. Accounts have to be kept by the trustee, showing the realisation of the estate, and the manner in which the proceeds are dealt with. The accounts are audited twice a year by the Board of Trade. When the trustee has realised all the assets and distributed the sum available, he applies to the Board of Trade for his release as trustee. He must give notice to the creditors of his intention to do so, and send to each of them a summary of his receipts and payments, showing, on the one hand, the amount the assets have realised as compared with the estimate placed upon them in the statement of affairs, and, on the other, the manner in which the amount received has been expended in payment of court and other fees, law costs, remuneration, and dividends to creditors. The Board of Trade audit the accounts to the close of the trusteeship, hear any objections by creditors to the granting of the release, and either grant it or refuse it until the trustee has complied with their requirements.

J. F. G. PRICE

Simple Brackets. Simplifying Expressions in Brackets. Multiplication of Simple Expressions. Examples and Answers to Examples.

MULTIPLICATION IN ALGEBRA

SIMPLE BRACKETS

18. As already explained, an expression that is to be treated as a whole is put between brackets. If we wish to *add* the expression to some other expression, we may enclose it in brackets and put the sign + before the brackets.

Thus, $a+b+(2a-b)$ means that $2a-b$ is to be added to $a+b$. But we know that to add an expression to another, we simply write down all its terms, with their signs unchanged, after the other expression.

It follows, then, that *if a pair of brackets is preceded by the sign +, the brackets may be omitted.*

Again, if we wish to *subtract* an expression, we may enclose it in brackets and prefix the sign −. But, to subtract an expression, we write down all the terms, with their signs changed [Art. **16**.]

Therefore, *when a pair of brackets is preceded by the sign −, the brackets may be omitted if we change the signs of all the terms between the brackets.*

Thus, $a+b-(2a-b)$ is equivalent to $a+b-2a+b$. For, the terms in the brackets are $+2a$ and $-b$, and, if we omit the brackets, we must change these into $-2a$ and $+b$.

19. Conversely, we have

Any number of terms of an expression may be enclosed within brackets with the sign + prefixed, the sign of every term remaining unaltered.

Any number of terms of an expression may be enclosed within brackets with the sign − prefixed provided the sign of every term put between the brackets be changed.

20. In simplifying an expression which has brackets placed within brackets, it is best to begin with the innermost pair, applying the rules given in Art. **18** to the removal of each pair.

Example. Simplify the expression

$$2b-[a-\overline{2a+b}+\{b-a-(-2b+3a)\}]$$

The expression

$$\begin{aligned} &=2b-[a-2a-b+\{b-a+2b-3a\}]\\ &=2b-[a-2a-b+b-a+2b-3a]\\ &=2b-a+2a+b-b+a-2b+3a\\ &=\underline{5a\ \textit{Ans.}}\end{aligned}$$

EXPLANATION. The vinculum and pair of brackets ( ) contain no other brackets, so we remove these first. The sign before the vinculum is −, therefore the terms under the vinculum, *viz.*, $+2a$ and $+b$, will become $-2a$ and $-b$ when the vinculum is removed. Similarly, since there is a − sign before the brackets ( ), the terms $-2b$ and $+3a$ will become $+2b$ and $-3a$ when the brackets are removed. We next take the pair { }, simply having to write down all the enclosed terms, with their signs unaltered. We now remove the pair [ ], by changing the signs of the enclosed terms, since a − sign precedes the bracket. Finally, we collect the like terms.

EXAMPLES 3

Simplify, by removing the brackets and collecting like terms

1. $2a-[b-\{a-(2b+a)\}]$
2. $3x-[1-\{3x+(1-\overline{3x-1})\}]$
3. $a+b-[-(c-a)+\{2b-\overline{a+c}\}]$
4. $-\{-(1-\overline{1+2})\}-[2+\{1-(2+3)\}]$
5. $x^4-\{x-3x^3-(x^2+\overline{x-1})\}-[-3-\{-x^4-(3x^3+x^2+1)\}]$
6. $\frac{1}{2}x-(\frac{3}{2}y+\frac{1}{4}z)-\{\frac{1}{2}x+(\frac{1}{2}y-\frac{1}{4}\overline{z+x})\}$.

MULTIPLICATION

21. In Arithmetic [Art. **15**] the multiplication of one whole number by another was defined to be the sum of as many repetitions of the one number as there are units in the other number. 12×5 means that we are to add together 5 repetitions of the number 12. We saw, however, on reaching fractional quantities [Art. **82**] that we had to put the definition in another form, *viz.*, to multiply one number by another we do to the one what we do to the unit to obtain the other. Thus, if we multiply 3 by 4, the definition states that since 3 is $1+1+1$, therefore, 3×4 is $4+4+4$.

By means of this definition we can find a meaning for multiplication by a negative quantity. Suppose we wish to multiply 3 by −4. To subtract 4 is the same as subtracting four units in succession, *i.e.*,

$$-4=-1-1-1-1.$$

Hence, by definition, to multiply 3 by −4, we must subtract 3 four times in succession, *i.e.*,

$$3\times(-4)=-3-3-3-3=-12.$$

Similarly, we can multiply −3 by −4. For

$$-3=-1-1-1.$$

Therefore,

$$\begin{aligned}(-4)\times(-3)&=-(-4)-(-4)-(-4)\\&=4+4+4\ \text{[Art. 18]}\\&=+12.\end{aligned}$$

We can proceed in the same way with any other quantities, whether whole numbers or fractions, positive or negative. Hence, we see that

(i.) $a\times b=ab$,
(ii.) $a\times(-b)=-ab$,
(iii.) $(-a)\times b=-ab$,
(iv.) $(-a)\times(-b)=+ab$.

These four results are usually stated thus: *Like signs give +, unlike signs give −.* This is the *Law of Signs.*

22. It was proved in Arithmetic that $4 \times 5 = 5 \times 4$, and that $\frac{3}{5} \times \frac{4}{11} = \frac{3 \times 4}{5 \times 11}$. But $3 \times 4 = 4 \times 3$, and $5 \times 11 = 11 \times 5$. Hence

$$\frac{3}{5} \times \frac{4}{11} = \frac{4 \times 3}{11 \times 5} = \frac{4}{11} \times \frac{3}{5}.$$

Therefore, for *positive* values of a and b, whether a and b are whole numbers or fractions, we have

$$a \times b = b \times a.$$

But the result of Art. 21 showed that the *absolute* value of the product is independent of the signs, so that $ab = ba$ is true for *all* values of a and b, positive or negative.

It easily follows that

$$abc = a \times b \times c = (a \times b) \times c$$
$$= (b \times a) \times c = b \times a \times c = bac.$$

In the same way we get $abc = acb$, and so on. Hence, *the factors of a product may be taken in any order.* This result is called the *Commutative Law.*

23. From our definitions of *power* and *index* we have

$$a^3 = aaa \text{ and } a^4 = aaaa$$
$$\therefore\ a^3 \times a^4 = aaaaaaa = a^7 = a^{3+4}.$$

Again,

$$5a \times 3a^2$$
$$= 5 \times a \times 3 \times a \times a$$
$$= 15aaa, \text{ since the factors can be taken in any order}$$
$$= 15a^3 = 15a^{1+2}.$$

Thus, *the index of the product of two powers of the same letter is equal to the sum of the indices of the factors.*

This result is called the *Index Law.*

24. Making use of the law of signs, the commutative law, and the index law, we are now able to find the product of any *simple* expressions, *i.e.*, expressions which contain only one term.

Example 1. Multiply $4x^2y$ by $3x^4y^2$.

$4x^2y \times 3x^4y^2 = 4 \times 3 \times x^2 \times x^4 \times y \times y^2$, by the commutative law
$= 12x^{2+4}y^{1+2}$, by the index law
$= \underline{12x^6y^3 \ Ans.}$

Example 2. Multiply $7xyz^2$ by $-2x^2y$.

$7xyz^2 \times (-2x^2y) = -(7xyz^2 \times 2x^2y)$, by the law of signs
$= -7 \times 2 \times x \times x^2 \times y \times y \times z^2$, by the commutative law
$= -14x^{1+2}y^{1+1}z^2$, by the index law
$= \underline{-14x^3y^2z^2 \ Ans.}$

We see, then, that the result can be written down at once, without putting down all the steps shown above. We (i.) write down the sign of the product; (ii.) multiply together the numerical coefficients; (iii.) write each letter that occurs, the index of its power being found by adding the indices of that letter in the factors.

Example 3. Find the continued product of $3a^2$, $2bc^2$, and $-4ac$.

$(-3a^2b) \times (2bc^2) \times (-4ac) = \underline{24a^3b^2c^3 \ Ans.}$

In determining the sign, we see that the sign of the product of the first two terms is $-$. The sign of the product of this result and $-4ac$ will therefore be $+$.

EXAMPLES 4

Multiply

1. $4a^2$ by $7a^5$.
2. $-3x^3$ by $-4x$.
3. xy by $-2xy$.
4. $3abc^5$ by $-2a^4c$.
5. $-11ca$ by $-4ab$.
6. $2a^4b^6c$ by $-abc^3$.
7. abx by bcy.
8. $-5cx$ by -4.

Find the continued product of

9. $4ab, -3ca, 5bc$.
10. $-a^3bcx, 2b^2x^2, 3ac$.
11. $-x^2yz, -y^3z^2, -x$.
12. $6byz, -4c^2xy, 2bz^2, ax^2$.

If $x = -2$, $y = 3$, $z = 0$, $a = -1$, find the value of

13. $2ax^2y$.
14. $5a^2y^3$.
15. $3xy + 4y^2z - 5a^3$.
16. $(2x + 3y)^2 - 3(a^2 + z^2)$.
17. $2ax - \{3x^2y - \overline{4xyz - a^3}\}$.
18. $\sqrt[3]{6ax^5y^2}$.
19. $\sqrt[3]{\frac{a^2 + xy}{5x^3}}$.
20. $\sqrt{6ax^3y} \times \sqrt[4]{12a^2x^2y^3}$.

Answers to Algebra

EXAMPLES 1

1. $3a^2 = 3.3.3 = 27$ *Ans.*
2. $4abc^2 = 4.3.1.2.2 = 48$ *Ans.*
3. $a^3 + b^3 + c^3 - 3abc = 3^3 + 1^3 + 2^3 - 3.3.1.2 = 27 + 1 + 8 - 18 = 36 - 18 = 18$ *Ans.*
4. $\frac{a + b - c}{a + c - b} = \frac{3 + 1 - 2}{3 + 2 - 1} = \frac{2}{4} = \frac{1}{2}$ *Ans.*
5. $\frac{1}{2}a^2bc^3 - \frac{1}{3}a^3bc = \frac{1}{2}.9.1.8 - \frac{1}{3}.27.1.2 = 36 - 18 = 18$ *Ans.*
6. $\sqrt{2x^2 + 3y^2 + 4z^2} = \sqrt{2.36 + 3.9 + 4.\frac{1}{4}} = \sqrt{72 + 27 + 1} = \sqrt{100} = 10$ *Ans.*
7. $\sqrt[3]{\frac{3xy}{z^2}} = \sqrt[3]{\frac{3.6.3}{\frac{1}{4}}} = \sqrt[3]{3.6.3.4} = \sqrt[3]{3^3.2^3} = 6$ *Ans.*
8. $\sqrt{x + 3} + \sqrt[3]{x + 4y^2 + 7z^3} = \sqrt{6 + 3} + \sqrt[3]{6 + 4.9 + 7.\frac{1}{8}} = \sqrt{9} + \sqrt[3]{6 + 36 + \frac{7}{8}} = 3 + \sqrt[3]{42\frac{7}{8}} = 3 + \sqrt[3]{\frac{343}{8}} = 3 + \frac{7}{2} = 10\frac{1}{2}$ *Ans.*
9. When $x = 3$, $x^2 - 7x + 12 = 9 - 21 + 12 = 21 - 21 = 0$. When $x = 4$, $x^2 - 7x + 12 = 16 - 28 + 12 = 28 - 28 = 0$. When $x = 5$, $x^2 - 7x + 12 = 25 - 35 + 12 = 37 - 35 = 2$.
10. $(ad + bc)^2 - 2(2a^2 - 3b^3) + (c^2d - 2b)^2 = (0 + 2)^2 - 2(32 - 24) + (0 - 4)^2 = 4 - 16 + 16 = 4$ *Ans.*

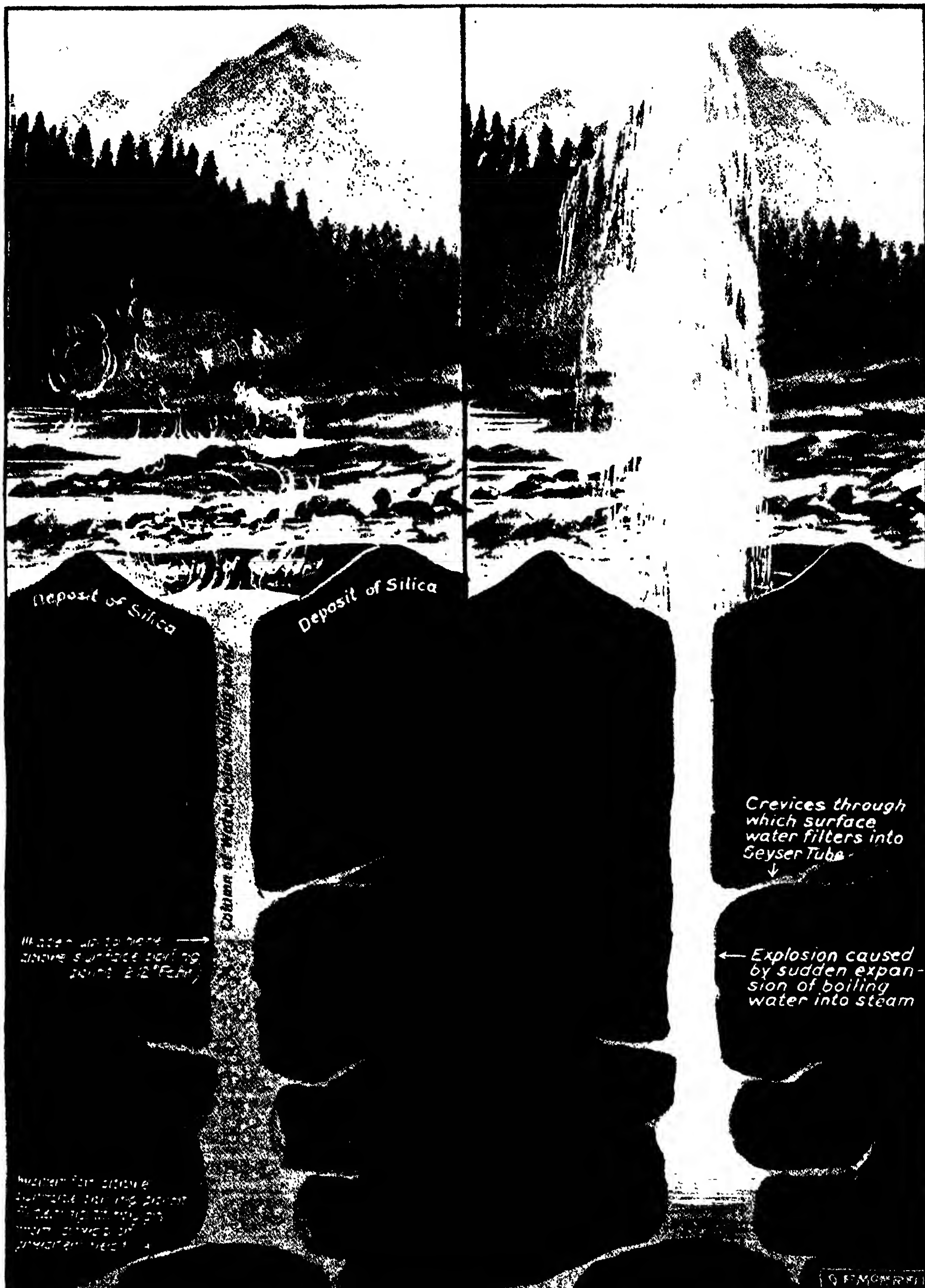
EXAMPLES 2

1. $ab + ca + bc$.
2. $-2x^3 - x^2 + x + 2$.
3. $\frac{1}{2}x - y + \frac{1}{2}z$.
4. $-2ax^2 - 2a^2x$.
5. $-2ab - 3cd + 4bd$.
6. $-x^3 - 8x^2y + 5xy^2 - y^3$.
7. $-\frac{1}{6}a - \frac{7}{12}b + \frac{3}{4}c$.
8. $-7a^4 + 3a^3 + a^2 + 3a - 4$.
9. $x^3 + 4x^2 + 2x - 2$.
10. $4 - 3y - 4y^2 + 5y^3$.

NOTE.—The answer to Examples 12, No. 2 (page, 1200), should read as follows: $21{\cdot}9236\dot{3}\dot{6} - 9{\cdot}389\dot{3} = 12{\cdot}534\dot{2}9770274324\dot{7}$.

H. J. ALLPORT

THE NATURAL FOUNTAINS OF THE EARTH



three or four varieties of geysers, and this diagram explains the intermittent type. The left-hand picture shows the temporarily quiescent stage. Bearing in mind that the boiling-point of water, 212° F. at sea level, increases with the depth, it can easily be understood that a body of hot water ascending from below, and much above 212°, is prevented from generating steam by the column of cooler water in the tube above it and by the added atmospheric pressure. But this very hot water gradually ascends the tube until it reaches a point at which steam can generate. For example, when the water filtering in below is 260° F., it cannot generate steam until it reaches to about 45 ft. from the surface. Then the steam rapidly produces the effect shown in the right-hand picture, for steam occupies a space 1650 times that of water, and the sudden expansion resulting from its generation blows out high into the air the 45 ft. column of water above it.

The True Conception of Good Manners and the False. The Sympathy and Understanding that Win Friends.

MANNERS AND TACT

The late Professor Lecky, in the most practical and popular of his books—his "Map of Life"—argues, with compelling conviction, that good manners and tact, if allied with sound judgment, lead to a success that is out of all proportion to the success which may be obtained by purely intellectual qualities, or even by imperious strength of will. Almost every observer of life on a wide scale will agree with him. The young man whose manners are, in Bacon's phrase, "letters of perpetual recommendation" has more than half won the battle of life. Emerson crystallised the case into a sentence: "Give a boy address, and you give him the mastery of palaces." Attractive manners, that spring unforced, as if from a man's deepest nature, and fit him without a flaw, dissolve opposition, disarm even envy, clear the way, ensure a welcome, and go far towards attaining whatever end is being sought. But the possession of such manners, and especially of the tact that completes them, is a complex problem, raising many curious questions, some of which may be mentioned here with advantage.

If perfect manners are such a talisman, why is it that a considerable section of the British working class, who are proud of their children and cherish ambitions on their behalf, not only do not recognise the helpfulness of good manners, but regard evidence of them with a feeling approaching resentment?

Some will say that this imputation is a libel. It would be a libel if it were applied to all, or to a majority. For there are working-class homes where gentlemen and ladies live, and bring up their children into nice ways, with kind feelings and an unaggressive self-respect, so that their manners will compare with those of the best-bred families in the land. And there are also families who absorb a tradition of good manners from association with people who have "a heritage of long ancestral ease." Some reared on great estates, for example, seem to be born into a graceful bearing, without being subservient or parasitic. But when large allowances have been made for the mannerly, a residue of the working class remains that regards good manners with a sort of surly suspicion, and by communicating the feeling to its children seriously handicaps them for life's strenuous race.

Why is this? Positive excuses cannot be offered for such obvious unwisdom, but some palliatives may be mentioned. When a tradition gets hold in favour of plain, blunt dealing, with a hearty dislike of fine ways, which are looked on as "flummery" that borders on deception, it is not easy to introduce a different ideal through the younger members of the family. Any change is felt to imply a rebuke to the elders, and their system of studied candour. The result is that there are often two codes of manners, as there are two vocabularies — the contrasted manners and vocabulary of the home on the one hand, and of the school on the other hand. The young people grow up vacillating between the two types of bearing and language.

The writer once alighted at a rural railway station with a city football team, who, on the platform, in their excitement were speaking the local dialect with such breadth and richness that he felt his loss, from a philological point of view in not having chanced to be in the carriage with them on the journey out. He admiringly inquired who they were, and was told they were the Pupil Teachers' First Eleven, on their way to meet a team of waterworks' navvies. It was evident that in the match there would be no linguistic misunderstandings.

If the adoption of a recommendatory standard of speech and bearing be so difficult on the social level implied in the last paragraph, how much greater must be the miracle of forming a graceful and easy manner, with speech that is pleasing and no disadvantage, in the poorer homes from which many children come who have their faces set towards distant goals of success!

It must be remembered that many working-class people have few opportunities of judging good manners as they are practised by men in whom such manners are natural, instinctive, and wholly fitting. They see plenty of sham good manners that ring with a false note. They know the pushing man whose jaunty air is a part of his business—a very unfortunate part, though he is not aware of it. They know the sort of manners into which salesmen so often fall, and which amount only to routine flattery with a purpose. They know the atrociously bad "superior" manners of people who arrogate to themselves a lofty position from which they survey the world with high-pitched criticism. They know the overbearing manners of persons in authority who, on occasion, "whip up" those serving under them.

These and similar types of manners, observable in many who assume a position somewhat above the ordinary person, do not commend themselves to plain, sincere people whose independence suggests that they shall "stand no nonsense." And the instinct is sound, for the rough straightforwardness of ordinary workmen with each other is palpably more attractive than sham fine manners without inherent grace. This being so, can anyone wonder that a certain degree of suspicion attaches to the cultivation of a superior bearing? Is it likely that the parents of clever boys born to comparative poverty, but bound at last to attain considerable distinction, will have sufficient imagination and foresight to feel how great the advantage of really good manners would be to their children, and how serious their initial deprivation is? The position of the unhelpful parent is often natural enough from his own point of view, and calls for a large allowance of charity.

Are all good manners innate? Or can they be acquired? If so, how? The truth behind these inquiries seems to be that a great deal can be done to train people into good manners, but that in the end the success of the training depends on whether the character and disposition are such that taste and kindness become instinctive, though at first they may have been overlaid by faults caught from unfortunate surroundings. Emerson probed the question to its inmost heart when he said, "You cannot rightly train a man to an air and manner except by making him the kind of man to whom that manner is a natural expression." Faults may be pruned away, obstructions may be cleared from the windows of the soul, but at best manners depend on the quality of the soul that looks forth.

Of course, the early, insensible training of the home and school is the best for eradicating faults and establishing a sound ideal of good manners. It has been said that good manners cannot be acquired except by living with well-bred people from the first, but that assertion is much too sweeping. It does not need wide experience to find men with the best manner who were spoilt at home, owing to the inability of their parents to manage children, but who, having the right material in them, though hidden by parental futility, were made into men at school. One has heard a gentleman say, with remorseful truth, "What a cub I must have been when you first knew me!" Further, it is by no means impossible for a man who had no training at home, and no character-forming school experience, to acquire a perfect bearing during a few years' experience in cultured circles. Many a doctor whose manner constitutes half his power was once poor and socially inept.

But in all such cases of acquirement of charming and convincing manners a swift and fine perception has been at work, taking a true measure of surrounding circumstances and personalities, and feeling instinctively what to avoid and what to adopt. Men and women with this gift of instant perception, particularly if they have sweetness of disposition—for, as has been said, the saint is at home everywhere—make their own manners, and always make them aright. It may be so with the simplest and most uneducated. From the clarity of mind and heart of the wholly untutored may spring both charm and dignity. Still, the average person needs training in manners—at home, at school, and possibly from his wife, whose perception, probably, is swifter than his own. Few are beyond improvement, and most of us need some pruning and stimulation.

What part does etiquette play in good manners? Observation from the point of view of fulness of years shows that etiquette is much more likely to be undervalued than overvalued by the man who is strongly making his way in the world.

It can only be overvalued by supposing that it ensures good manners. Obviously it can do nothing of the kind. A man may keep sedulously every rule that society favours, and yet be a highly uncomfortable creature to himself and others. Good manners only begin when all that the rules of etiquette stand for has been thoroughly absorbed and assimilated and the rules themselves are unneeded. They are valuable as a scaffolding for building up a sense of propriety, but while they are being consciously conformed to they hamper ease, for Bacon's dictum respecting manners remains eternally true: "If a man shall labour much to express them, he shall lose their grace."

None the less, the rules of etiquette are extraordinarily wise, and to undervalue them is a mistake, and often an impertinence. They are the seeding of the wisdom and experience of society—a seed from which good manners readily grow. By these conventions society protects itself from the blundering of people who lack a natural sense of refinement; and if the rules be closely examined they will be found to embody an amazing amount of good sense and right feeling. If any temporarily accepted tenet is not found to work well, it is soon modified by that general social taste which somehow shapes the code of manners in use among the well bred. We have only to watch in mixed society those who conform to accepted etiquette, and those who do not, to feel how useful—and, indeed, how genuinely attractive and graceful—fully assimilated etiquette becomes. Whoever disdains it loads himself socially with a heavy handicap that may spell failure.

It is a certainty that the man, and still more the woman, who fails to appreciate the value of the everyday etiquette which holds the field among well-bred people, and who neglects to practise it, will be looked down on by many who, possibly, are intellectually inferior, and he may place not only himself but his friends in awkward predicaments. Only a very thick skin will carry one through life without discomfort in case social usages are disregarded. For example, the man who is beginning to be successful, but does not see why he should bother with points of etiquette, at once "gives himself away" to the servants in any house he may enter as a guest, and, though he may not care about that, the likelihood is that his host will be made uncomfortable. Indeed, the man who blunders socially with a heavy foot spreads a sense of distress throughout any circle where refinement is a common safeguard, and he is sure to limit his own opportunities of knowing a wider range of people whose acquaintance would be an advantage.

If one were to try to find the most central of all words of warning in aid of good manners, it would be a warning against exaggeration. The well-mannered person never courts conspicuousness, never poses in the limelight, but is simple, open, sincere, with the knack of keeping within measure. Such a person radiates good manners like a soft effulgence. The effect may be seen in outward forms like dress. Men and women who can carry off exaggeration in dress, whether showy or dowdy, are very few in number. There must be a strong undercurrent of conceit, or daring, or dulness in people who suppose they can be either "loud" or slovenly in dress and do themselves justice, unless they are geniuses altogether above mundane considerations. The average person may well give some attention to that wise moderation and graceful fitness in dress which wins an instinctive acceptance from all onlookers. That is the true test of being well dressed.

Emerson, who wrote more words of insight about manners than perhaps any other philosopher, declared that though "the tell-tale body is all tongues," it is the eye that is the finest index to behaviour. "A man carries in his eye the exact indication of his rank in the immense scale of men, and we are always learning to read it." And his conclusion of the whole matter was: "When a youth looks humble, yet manly, I choose him." That is a rule which the world instinctively follows.

The crown of good manners is tact. Tact is good manners in smooth yet vigorous action. It is the happy art of so managing men that you put them at their ease, create a pleasing impression, and advance the object you have in view without arousing any feeling of distrustful opposition. To do this one must have good manners to begin with, and follow on with all kinds of attractive qualities, for it demands perfect self-control, and therefore an unruffled temper, an instinctive understanding of varied character that can only be gained through strong and swift natural sympathy; and to be

really effective it must be backed by great strength. Tact has been well characterised as the finest of the fine arts.

In the book already mentioned, Mr. Lecky makes a careful analysis of tact and traces its effects. The tactful man, he says, will gain his point without ever appearing to antagonise anybody. With greatly inferior intellectual qualities he will pass in the race of life the brilliant, the witty, the ambitious, and the energetic who lack his agreeable knowledge of men and their management. Tact shows itself as much in what a man leaves undone as in what he does. It implies a perception of the finer shadings of character, and enables a man to place himself in touch with a great variety of dispositions, and to catch the more delicate notes of feeling to which grosser natures are insensible.

Without mentioning names, Mr. Lecky suggests that some of the greatest positions in public life have fallen to men of mediocre ability, when men of far greater personal power were available, and the choice has been due to the confidence created by unfailing tact. In this connection he develops the interesting theory that "the presence or absence of this gift [tact] is one of the chief causes why the relative value of different men is often so differently judged by contemporaries and by posterity—by those who have come in direct personal contact with them, and by those who judge them from without, and by the broad results of their lives." That is to say, Mr. Lecky held that men who gained great positions by the charm of tact have been over-estimated as to their inherent value to mankind by the men of their own day; and the historian, whose judgment is not warped by personal fascination, necessarily evanescent, is able to readjust the balance in favour of more original and potent personalities who lost the immediate rewards of popular favour because they were angular and unaccommodating.

The lesson of this historical estimate may be read around us in every grade of society, for perhaps the most palpable proof of the need for tact is to be seen in the universal unpopularity of men who are devoid of it. The tactless man may bristle with all the sterner virtues, and yet be unpopular to the verge of detestation. Everyone around may know he has these virtues, may admit them by word of mouth and in the secrecy of the heart, and yet be unable "to stand" his tactlessness. Faults they will forgive, so long as they are the outcome of an errant nature, but they cannot bear to be perpetually "rubbed the wrong way." And so the tactless man not only fails to make smooth his own path, but he positively raises obstacles in it by exciting the resentment of a multitude of plain people, who do not see why he should push his way through the world past them with barbarous angularity.

Tact, also, has this great advantage—it secures faithful and loyal service. Wages will not do this, however high they may be. They may quicken a man's self-interest into a better pace, but they do not control his actions from his heart. That is only done by the spirit in which men are treated, and the spirit that none can resist is that which finds honest expression through tact. Such tact need not necessarily be suave and soft-spoken, for there are many who always suspect suavity. It really depends on a sympathetic understanding of the person concerned, so that man speaks to man in the humour that suits the two; and out of that commerce of spirits devotion is born.

Probably of all positions held by those who serve, the one which demands the most tact is that of private secretary to a public man who occupies a position of great importance. The secretary must always have a great deal of knowledge which many desire but he has no right to communicate. Indeed, so far from giving information, he must not even allow inferences to be drawn from his manner. Yet he must not be repellent to those whose attitude is friendly, or even, for that matter, to the unfriendly. He should leave on all the impression not of a surly secrecy, but of being a genuine good fellow, open and well disposed. If there can be a greater sign of tact than popularity while holding faithfully a position of this confidential character, it must surely be found in the man who succeeds in extracting what he wants to know from such an expert in the art of genial and accomplished silence.

The call for tact is made incessantly on each of us, wherever we move among our fellow-men; and though no one can study his way into it, yet we may avoid the worst pitfalls of tactlessness if we remember that it is only by realising habitually the point of view of others that we can have the genuine good manners which merge into tact.

JOHN DERRY

Coastline. Mountain Systems and Tablelands. Roof of the World. Himalayas. River Basins. Inland Drainage. Climate. Isotherms. Rainfall. Political Divisions.

THE GRANDEUR OF ASIA

The Continent as a Whole. Asia, the largest of the continents (17,000,000 sq. miles), is surrounded by the ocean except in the west, where it is continuous with Europe. The frontier between the two does not correspond with natural features save in the Urals and Caucasus.

Coastline. The northern shores of Asia are washed by the Arctic Ocean, with one great gulf, the Kara Sea, shut in to the west by the island of Novaya Zemlya, and smaller gulfs, where the north-flowing rivers form estuaries.

The eastern coast is curiously symmetrical in the arrangement of its lands and seas. The lines of North-eastern Asia and the peninsula of Kamchatka, east of the Sea of Okhotsk, correspond closely in outline with (1) Amuria and Korea, east of the Yellow Sea; (2) China and the Island of Hainan, east of the Gulf of Tongking; and (3) Indo-China and the Malay peninsula, defining the Gulf of Siam. A sort of festooned fringe of islands extends from Kamchatka to the islands of the Malay archipelago, separating four enclosed seas from the main Pacific Ocean. These are (1) the Sea of Okhotsk, enclosed by Kamchatka, the Kurile Islands, and Sakhalin, and opening by the La Perouse Strait, between Sakhalin and the northern island of Japan, to (2) the Sea of Japan, enclosed to the east by the islands of Japan. The Strait of Korea in the south between the Kiushiu Island of Japan and the Korean peninsula, to (3) the East China Sea, enclosed on the east by the Lu-chu islands and Formosa. (4) The South China Sea is enclosed on the east by Formosa, the Philippine Islands, and Borneo, the largest island of the Malay archipelago. This archipelago, together with New Guinea, connects Eastern Asia with Australia, which many ages ago was part of the Old World.

The southern coast of Asia is washed by the Indian Ocean. Like Europe, it is broken into three south-running peninsulas; (1) the Indo-China peninsula in the east, separated from (2) India, the middle peninsula, by the Bay of Bengal; and (3) Arabia in the west, separated from India by the Arabian Sea, which opens to the Persian Gulf. West of Arabia is the narrow Red Sea, separating Asia from Africa, and divided from the Mediterranean only by the narrow Isthmus of Suez, across which a ship canal has been cut.

Mountains and Rivers of Asia. We have seen that Europe and Asia really form a single continent, and that the physical features of the two are continuous. Broadly speaking, Europe is a lowland in the north and a highland in the south, and these divisions are represented in Asia by the plains of Siberia in the north, and the mountains of Central Asia. South of the latter are a series of lowlands: Mesopotamia, or the lowland of the Euphrates, in the west; the lowlands of the Indus and Ganges, or the plain of India, in the centre—both of which we may compare with the plain of the Po at the base of the Central Alps—and smaller lowlands in the east, round the rivers of Indo-China. Beyond these lowlands is the tableland of Arabia in the west, which may be compared with Spain, and the tableland of the Deccan, occupying the southern half of the Indian peninsula.

The Mountains of Asia. More than half of Asia is over 1,500 ft. above sea level. Its vast and complicated mountain systems, far greater in area than the whole of Europe, are the greatest highland area in the world in length, breadth, and height.

We began our study of the central European highlands with the Fichtel Gebirge, and of the Alps with the St. Gotthard, and similarly, dealing with the immensely complicated relief in Asia, we shall begin by looking for a centre from which the principal mountains and rivers radiate. This we find in the Pamirs, where the frontiers of Britain, Russia, China, and Afghanistan meet. They form a desolate plateau, some 150 miles both in breadth and length, which the inhabitants well call the Roof of the World.

The Roof of the World. This is how the Roof of the World is described by a traveller approaching it from the north. "Approaching this interesting region from Kashgaria, one sees clearly how it has acquired the name of the Roof of the World. The Pamir mountains rise apparently quite suddenly out of the plain, from a height of 4,000 ft. above sea level at their base, to over 25,000 ft. at their loftiest summits, a massive wall of rocks, snow, and ice. Once through the gorges which lead up from the plains, one enters a region of broad, open valleys separated by comparatively low ranges of mountains. These valleys are known as Pamirs, a term applied by the natives of these parts to a particular kind of valley. In the Hindu Kush and Himalaya regions the valleys, as a rule, are deep, narrow, and shut in. But on the Roof of the World they seem to have been choked up with the débris falling from the mountains on either side faster than the rainfall has been able to wash them out, and so their bottoms are sometimes as much as four or five miles broad, and almost level. These Pamirs vary from 12,000 or 13,000 to 14,000 ft. above sea level—that is, the bottoms of these Pamir valleys are level with the highest summits of the Alps."

For the greater part of the year they are buried in snow, but during the few weeks of summer there is a fair abundance of coarse but nourishing pasture, which attracts a few wandering Kirghiz herdsmen and their flocks to this desolate region.

The Pamirs as a Mountain Centre. From the Pamirs radiate the chief mountain systems of Central Asia. These are (1) the Tian Shan, running north-east, in a direction which is continued by the Altai, Yablonoi, and other mountains which form the northern rampart of the mountain core of Central Asia. From the northern valleys of this rampart, which slopes to the vast plains of Northern Asia, descend the rivers of Siberia—the Ob, Yenisei, and Lena—while the great Amur, flowing east to the Sea of Okhotsk, gathers up the waters of the southern and eastern valleys. Between (1) the Tian Shan and (2) the Kwenlun, the next well-defined system radiating east from the Pamirs, are enclosed the Tarim basin and the tableland of Mongolia. Besides forming the southern wall of this plateau, the Kwenlun is, as it were, a natural stair leading to a still loftier plateau, whose valleys lie but a few thousand feet below the summits of its highest peaks. This is Tibet, the highest inhabited land in the world. The next system is formed by (3) the Karakoram, or Muztagh Mountains, and (4) the mighty Himalayas, the most imposing system in the world. Its northern ranges form the southern rampart of the Tibetan plateau, while the southern descend steeply to the plains of India, 20,000 ft. or more below.

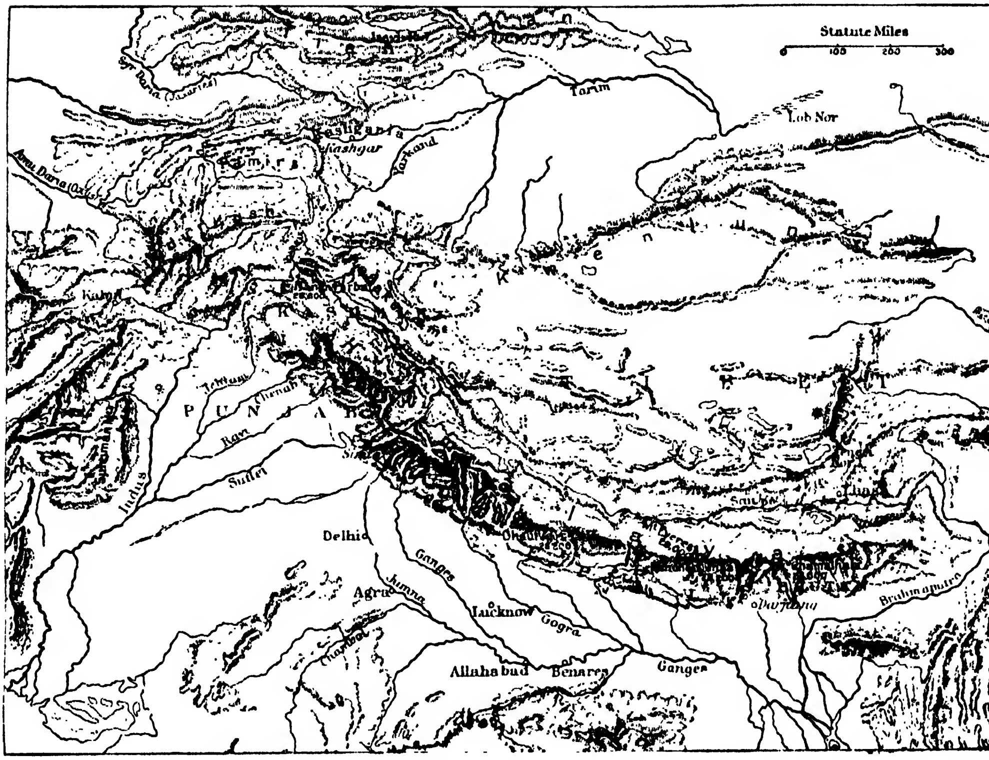
The Himalayas. No words, or even pictures, can give an idea of the wonders of the Himalayas. Seen from the plains of India, they consist of low hills, not over 2,000 ft., with ranges behind rising to 8,000 or 9,000 ft., and behind these again, to snowy summits, over 25,000 ft. At the base lies a broad strip of malarious jungle, called the Terai, with a heavy rainfall and continuous floods, so that the water-logged soil is pestilential with decaying vegetation. Above this is the forest zone. The ascent is very rapid. In 35 miles the railway to Darjiling, in the Sikkim Himalayas, climbs over 7,000 ft. "The whole range may be described as a stupendous stairway hewn out of the western border of the Tibetan plateau by glaciers and great rivers. It is cut into countless peaks and ranges, with valleys of corresponding depth, down which dash thundering torrents. The deep gorges of the rivers so interpenetrate the mountains as to carry a hot climate far along their banks, till the semi-tropic vegetation becomes almost overhung by snowy peaks." This is true only of the valleys opening south to the plains of India. Those enclosed between the ranges of the Himalayas are as terrible in their desolation as in the wild character of their scenery.

A Himalayan Road. Lord Curzon thus describes his march along the upper valley of the Hunza, a tributary of the Indus: "The river cuts a deep gash or furrows an uproarious channel in its descent from the watershed of the Pamirs. Big glaciers propel their petrified cascades to the very edge of the river. Sometimes the road is conducted round the edge of the precipices that overhang the torrent by artificial ladders and ledges, built out from the cliff with stones loosely laid upon supports of brushwood and timber jammed into the interstices of the rock. Over this vile stretch of country there are two tracks, the upper, or summer track, which avoids the river-bed, filled with a fierce and swirling torrent, and climbs to the summit of the cliffs, several thousand feet above the water, and the lower, or winter track, which can only be pursued when the melting of the snow by the hot summer sun is over, and the river dwindles to a number of fordable channels, across and amid the boulder-piled fringes of which the traveller picks his way." Up very similar roads lay a great part of our Army's ascent in 1904, by the gorges of the Sikkim Himalayas to the plateau of Tibet above. They made their way through dense forests, with a hothouse temperature and tropical vegetation, through woods of oak, chestnut, maple, ash and elm, through open snow and sprinkled pine-forest, emerging at last above the blazing rhododendrons which grow just below the snow line into open, undulating stretches of Alpine pastures, in full view of the great snow peaks.

Peaks of the Himalayas. Only a few of these can be named, for there are scores of peaks over 20,000 ft., presenting some of the finest scenery conceivable. In Kashmir, through which the Pamirs are approached from India by the Hunza Valley, the peak most admired by travellers is Nanga Parbat (26,600 ft.). In the Himalayas of Nepal is Dhaulagiri (26,800 ft.), while the monarch of the Sikkim Himalayas is Kanchenjunga (28,200 ft.), surrounded by peaks almost as high. Chamalhari (24,000 ft.) greatly impressed our troops who passed close below it in the Tibetan expedition, but the monarch of the Himalayas, as of the world, is Mount Everest (29,000 ft.), first seen from the Tibetan side in all its grandeur by European eyes in the summer of 1904. Hitherto the giant had been seen only from the south, almost completely hidden by the mighty peaks between.

A Glimpse of Mount Everest. "Towering up thousands of feet, a glittering pinnacle of snow, rose Everest, a giant among pigmies, not only on account of its height, but for its perfect form. To the east and west, but nowhere in its immediate vicinity, rise other great mountains of rock and snow, each beautiful in itself, but in no way comparing with the famous peak in solemn grandeur. It is difficult to give an idea of its stupendous height, its dazzling whiteness and overpowering size, for there is nothing in the world to compare it with." Thus writes the first Englishman who saw it, settling for ever the doubt whether still higher peaks might not exist on the Tibetan side. For the present, Mount Everest reigns as the unchallenged monarch of the world.

The Hindu Kush. Returning to the Pamirs, to reach which from Mount Everest we should have to cross Tibet and Kashmir

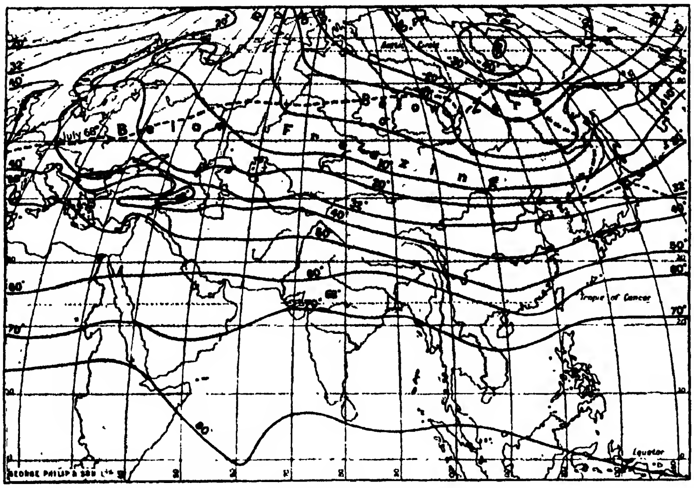


THE ROOF OF THE WORLD

by innumerable passes thousands of feet higher than the highest summit of the Alps, through some of the grandest and some of the most desolate scenery in the world, we now continue our examination of the mountain systems connected with the Roof of the World. They no longer run east, but west, interposing a mountain barrier hundreds of miles wide between the plains of India and the steppes of Russian Asia. They are known as (5) the Hindu Kush, the direction of which is continued west by the Elburz Mountains, at the southern margin of the Caspian Sea, to the highlands of Armenia, the centre of the West Asian mountain systems, and (6) the Suleiman Mountains, which run south, and form the western wall of the plains of India and the eastern rampart of the plateau of Iran, a smaller and lower Tibet.

The Rivers of Central Asia. We can now fill in the rivers connected with the great mountain systems of which the Pamir plateau is the centre. The glaciers of the western valleys of the Pamirs and the northern valleys of the Hindu Kush give birth to the feeders of the famous Oxus, or Amu Daria, which leaps down through stupendous and often impassable defiles, between walls of bare, treeless rock, to the lowlands of Turan, whose dry sands it crosses to the land-locked Sea of Aral, to which also flows the Jaxartes, or Syr Daria, from the Tian Shan. From the north-eastern glaciers of the Karakoram, above which peaks rise to over 28,000 ft., rushes down the Yarkand river, which unites with many other raging streams from the Tian Shan and Kwenlun to form the Tarim. The Tarim crosses the deserts of Eastern Turkestan, and loses itself at last in the marshes of the disappearing lake of Lob Nor. Greater than either of these is the mighty Indus, which rises deep in the fastnesses of the Himalayas, its upper valleys forming a series of appalling defiles, through which an inky torrent thunders at the base of sheer walls of rock, many thousands of feet in height. It is turned south by the wall of the Hindu Kush, and flows south-west at the base of the Hindu Kush and Suleiman Mountains to the Arabian Sea. As it crosses the plain of Northern India it receives many long tributaries from the Himalayas, the greatest being the Sutlej, which has risen not far from the Indus itself, and broken through range after range of the Himalayas in its wild course to the plains below. A third river, rising quite near the Indus and the Sutlej, but finding its escape along the Tibetan base of the Himalayas, is the Brahmaputra, whose course follows the direction of the Himalayas till these begin to break up and bend south. Then the Brahmaputra also turns south, and, leaping down the mountain terraces of Assam, flows at last to the delta of the Ganges. The Ganges is formed by the union of many great rivers, which thunder down in parallel valleys

from the southern slopes of the Himalayas, their sources not far, as the crow flies, from those of the feeders of the Indus and Sutlej, but separated from them by what are, for man, insuperable barriers.



JANUARY ISOTHERMS
The July isotherm of 68 deg. is indicated by a broken line

The Mountains and Rivers of Indo-China. In the wild and little-known regions on the frontiers of Tibet and Eastern China, at the eastern end of the Kwenlun, we have another of those central points from which a whole series of mountains and rivers radiate. Here the Hwang-ho, or Yellow River, of China rises in the mountain fastnesses of north-eastern Tibet, leaps down to the plateau of Mongolia, and breaks away south across the North China highlands, which spring from the eastern Kwenluns and mark the end of that long line of elevation, running from west to east, which we have traced from the shores of the Bay of Biscay to the eastern confines of Asia. Here, where it ends, internal convulsions have crumpled the Earth's crust into complicated folds, which diverge in all directions, north-east in the North China highlands, east in the highlands which separate the Hwang-ho from the Yangtse-kiang, the second great river of China, and south in the parallel ranges which lie east of the Himalayas and the valley of the Brahmaputra. A whole series of parallel valleys, running first east and then south, are filled by the tributaries of the Yangtse-kiang and by the upper courses of the rivers of Indo-China, the Irawadi, the Salwen, and the Mekong.

The Armenian Highlands. To the highlands of Armenia, between the Black Sea and the Persian Gulf, converge (1) those mountains which continue the direction of the Hindu Kush and form the northern rampart of the plateau of Iran, and (2) those which spring from the base of the Suleiman Mountains and are continued along the Persian Gulf to the mountains of Kurdistan, forming the southern rampart of the same plateau. From the Armenian highlands diverge to the west the northern and southern mountain-walls of the plateau of Asia Minor, the latter known as the Taurus Mountains. The rivers of the Armenian highlands are the Euphrates and Tigris, flowing from the southern valleys to the Persian Gulf, forming in their lower courses the plains of Mesopotamia, and the Aras or Araxes, flowing east, and separating Armenia from the Caucasus.

The Mountains of Eastern Asia. Volcanic activity is very conspicuous in Eastern Asia, where a broken chain of volcanic mountains runs through Kamchatka, the Kurile Islands, Japan, the Luchu Islands, the Philippines, and some islands of the Malay archipelago, where disastrous manifestations of volcanic energy occur from time to time.

Basins of Inland Drainage. We saw that one large river of Europe, the Volga, flows, not to the open sea, but to the land-locked Caspian, which occupies part of a great depression which may be traced as far as the Sea of Aral. Areas drained in this way to lakes or inland seas are called basins of inland drainage. We have had other examples in the Amu Daria and Syr Daria, both flowing to the Sea of Aral, and in the Tarim, which loses itself in the marshes of the vanishing lake of Lob Nor. The total area of inland drainage in Asia is estimated at 4,000,000 square miles, an area greater than the whole of Europe.

The Desiccation of Asia. Lake Lob Nor is disappearing because it is gradually drying up. There is some evidence to show that the climate of Asia is probably slowly becoming drier. Not merely are some of the lakes and rivers shrinking, but the desert sands seem to have invaded once fertile tracts. "Whole kingdoms have disappeared, many cities have been swallowed up in the sands, and certain tracts formerly accessible to travellers can no longer be visited owing to the total absence of water and vegetation."

Climate of Asia. We now know enough about geographical laws to find out a great deal about the climate of Asia. We have many data to go upon. In the first place, Asia stretches from about lat. 77° N. to within 100 miles of the equator, which crosses the islands of Sumatra and Java. This gives every possible variety of climate so far as this is affected by latitude. The regions round the Caspian and Aral Seas are below sea level, while Mount Everest is nearly six miles above it. This gives us every variety of climate so far as this is determined by elevation. Thirdly, the continent is enormously longer and broader than Europe, and on one side it is surrounded by the land masses

of Europe and Africa, so that no oversea winds can come from that quarter. Further, while Europe is broken up into peninsulas and inland seas, Asia is extremely compact; so that while places in the centre of Europe are only hundreds of miles from the sea, in the centre of Asia they may be thousands; and between them and these distant seas are interposed ranges of lofty mountains which intercept all oversea winds. Putting all these facts together, we should say (1) that the climate of Asia is very varied, and (2) everywhere extreme, but (3) most extreme in the centre of the continent, and (4) that, except round the margin of the Pacific and Indian Oceans, the rainfall must be scanty, and (5) that the interior must be practically a rainless desert. These conclusions present exactly the real state of the case.

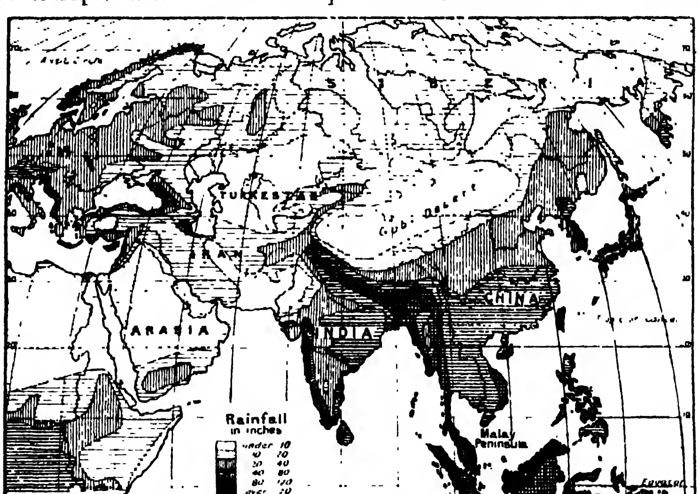
January Isotherms. In the maps which show the isotherms for January, we see the distribution of winter cold. We do not expect to find the great southward sweep of the winter isotherms which was so marked in the case of Europe, for this indicated a change from oceanic to continental climate. There is no such sharp transition in the case of Asia, which has the continental climate of Russia in a more intense form. The increasing severity of the winter cold as we go east is indicated by a steady instead of a sudden dip southwards. The isotherm of 32°, indicating freezing-point, which we traced in Europe as far south as the Black Sea, crosses the Caspian Sea, the Upper Oxus, and the lands north of the Himalayas, and then curves northwards through Korea, and north of Honshiu, the largest island of Japan. South of this line, which runs much farther south than the most southern point of Europe, there are no continuous frosts in the plains, though any degree of frost may be experienced at a sufficient elevation.

North of this isotherm frost lasts weeks or months, its severity and duration increasing as we go farther north, higher, or farther into the interior. The line of 0° F., indicating 32° of frost, includes most of the north-eastern part of the continent, and this is not the minimum winter temperature in Northern Siberia, for at Verkhoyansk it is under −50° F. South of this isotherm of 32° the combined influence of low latitude and proximity to the sea is markedly felt. The isotherm of 50° is comparatively near that of 32°, and the lowlands of Arabia, India, Southern China, and Indo-China have winters as warm or warmer than this. The winters of the southern lowlands of the three peninsulas are considerably warmer than the summers of the Thames Valley, which records prove to be one of the warmest parts of the British Isles.

July Isotherms. The summer isotherms show us, as we might expect, that the hottest summers occur in the southern part of the continental area proper, in which we may include most of Arabia, as the seas on either side are too narrow for cooling winds to develop. The true peninsular regions—the extreme south of Arabia, the Deccan, and Southern Indo-China—are somewhat cooler, though, of course, very hot. The isotherm of 68°, the summer temperature of the hotter parts of Central Europe, extends considerably north of Lake Baikal, but sinks southwards in Amuria, and passes completely north of Honshiu. Even in the tundra the summer temperature is as high as 50°. As the winter temperature of the same area is many degrees below freezing-point, the range of temperature which is experienced is enormous, especially in the centre and east.

Rainfall. Turning to the rainfall, we find that five great areas—(1) in Northern and Eastern Siberia, (2) in Russian Turkestan, (3) in Chinese Turkestan, (4) in Iran, and (5) in Arabia—receive less than 10 in. of rain in a year, and are rainless deserts except where irrigation is possible. These are surrounded by equally extensive regions where the annual rainfall is under 20 in.—as dry, that is, as the drier parts of Spain and Russia. The only well-watered regions are maritime China, Indo-China, and India south of the desert, round the Lower Indus. Parts of Southern China, North-east India, Burma, Siam, and the Malay Peninsula have a very heavy rainfall, as have also the Western Ghats, the western mountains of peninsular India, and the Malay Archipelago.

The Monsoons. Some of these wet areas lie in the equatorial belt of rain at all seasons,



THE RAINFALL OF ASIA

but much of the rainfall of Southern China, India, and a small wet area in South-west Arabia is brought by the summer monsoon, the nature of which has already been explained and illustrated in the chapter entitled "The Climates of the World" [pages 150 and 151].

The Bursting of the Monsoon. Réclus, the great French geographer, has finely described, the breaking of the monsoon. "The monsoon is one of the most majestic of terrestrial phenomena. The spectacle presented at its first approach may easily be contemplated from any headland of the Western Ghats which commands at once a view of the sea, the coast, and the mountain gorges. The first storm-clouds, forerunners of the tempest, usually gather between the 6th and the 18th of June. On one side of the horizon the coppery vapours are piled up like towers, or, to use the local expression, massed like elephants going into battle. As they move slowly towards the land, one half of the firmament becomes densely overcast, while not a speck sullies the deep azure in the opposite direction. On the one hand, mountains and valleys are wrapt in darkness; on the other, the outline of the seaboard stands out with intense sharpness. The surface of the sea and river assumes the metallic hue of steel, and the whole land, with its scattered towns, glitters with a weird glare. As the clouds strike the crags of the Western Ghats the thunder begins to rumble, the whirlwind bursts over the land, the lightnings flash incessantly, the peals grow more frequent and prolonged, and rain is discharged in torrents. Then the black clouds are suddenly rent asunder, the light of day gradually returns, and all Nature is again bathed in the rays of the setting sun."

Heavy downpours occur almost daily while the monsoon lasts, filling the dry river channels, and supplying abundant water for irrigation. The failure of the monsoon means famine and the loss of millions of lives.

Natural Vegetation Zones. These are now familiar. In the north is the tundra, snow-covered and lifeless for more than half the year, but with a brief beauty of flower and berry in summer, when the wandering tribes find abundant pasture for their reindeer, and the flooded rivers swarm with fish. Vast forests, penetrated only by the rivers and the thin ribbon of the Siberian railway, stretch between the tundra and the steppes of Central Asia, which pass into deserts in the rainless regions already spoken of. All these we have seen more or less developed in Europe. What is new is the rich tropical vegetation of the monsoon lands, which reaches its most luxuriant development in the magnificent forests of the Malay Archipelago. Stanley's graphic account of similar forests in Central Africa has already been quoted [see page 554], and the forests of Malaysia are, if possible, still more luxuriantly beautiful.

Animals. It is probable that most of our domesticated animals came originally from the steppes of Asia, which are still the home of immense flocks and herds, often belonging to wandering tribes which follow them from pasture to pasture. The camel is used in the desert lands adjoining the steppes. In the mountains of Central Asia are many wild animals, including the great wild sheep; the yak—an ox—is wild in the high pastures of Tibet, and is used as a beast of burden over the higher passes, some of which are not far short of 20,000 ft. South of the mountain barrier which crosses Asia new animals are found. The buffalo is the draught animal in India and China, and in the former country and Indo-China the elephant is used for heavier work and for show occasions. Snakes and tigers haunt the jungle, the latter animal being found as far north as Korea. The forests of northern Asia are the home of many fur-bearing animals, and the reindeer makes life of a sort possible in parts of the tundra.

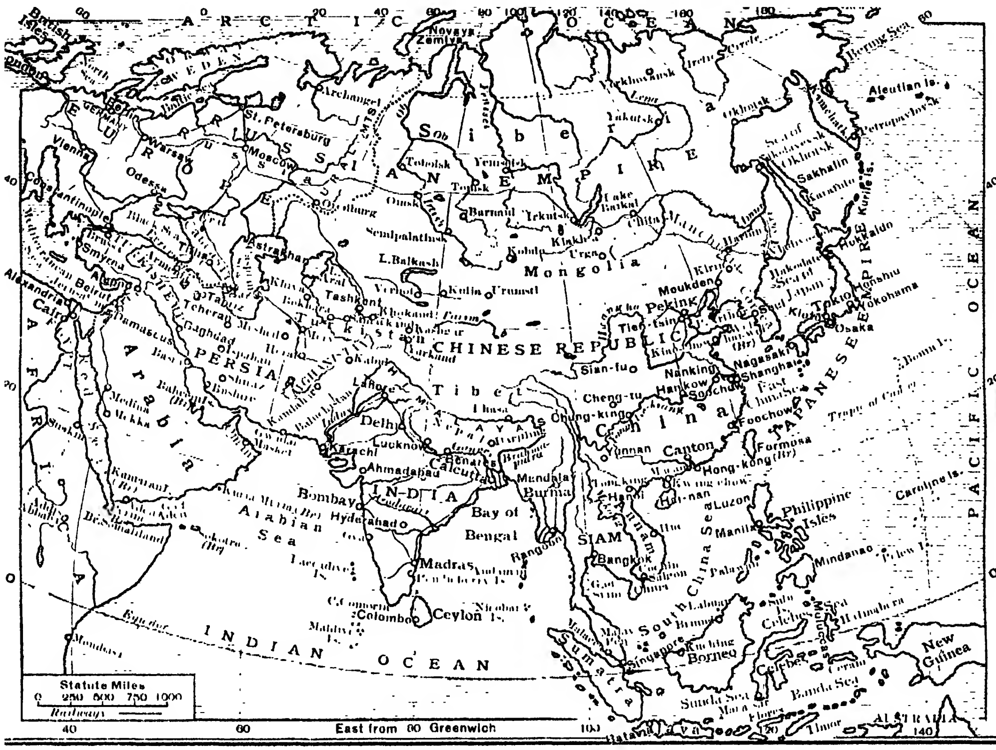
Political Divisions. The largest Asiatic Power is Russia, whose dominions—6,294,000 square miles—stretch from the frontier of Europe to the Pacific Ocean. Its southern boundary runs east from the southern end of the Caspian Sea to the Pamir plateau, follows the Tian Shan and other mountains bounding the Mongolian plateau, coincides with the Amur as far as the Usuri, and then runs south along the frontier of Manchuria to the Korean frontier. Conterminous with Russia from the Pamir plateau eastwards is China—4,278,000 square miles—which extends south to the Himalayas and the frontiers of Burma and Indo-China, and west to the Pacific.

The eastern part of the Indo-China peninsula is French (256,000 square miles), and the remainder belongs to Siam (200,000 square miles) and Britain. The British dominions—2,000,000 square miles—are India, its eastward extension, Burma, a strip of the south coast of Arabia, Ceylon, the extreme south of the Malay Peninsula, Hong-Kong and Wei-hai-wei in China, and part of Borneo. Afghanistan—250,000 square miles—lies between north-west India and south-west Russia. Persia—630,000 square miles—stretches between the Caspian and the Persian Gulf, while Turkey controls Asia Minor, Armenia, Kurdistan, Syria, and most of maritime Arabia—430,000 square miles. The centre and south-east of Arabia are independent. Off the coast of Eastern Asia is the island empire of Japan, including Formosa and Korea—261,000 square miles. The Philippines belong to the United States. The rest of the archipelago is Dutch, with the exception of the British possessions we have already mentioned.

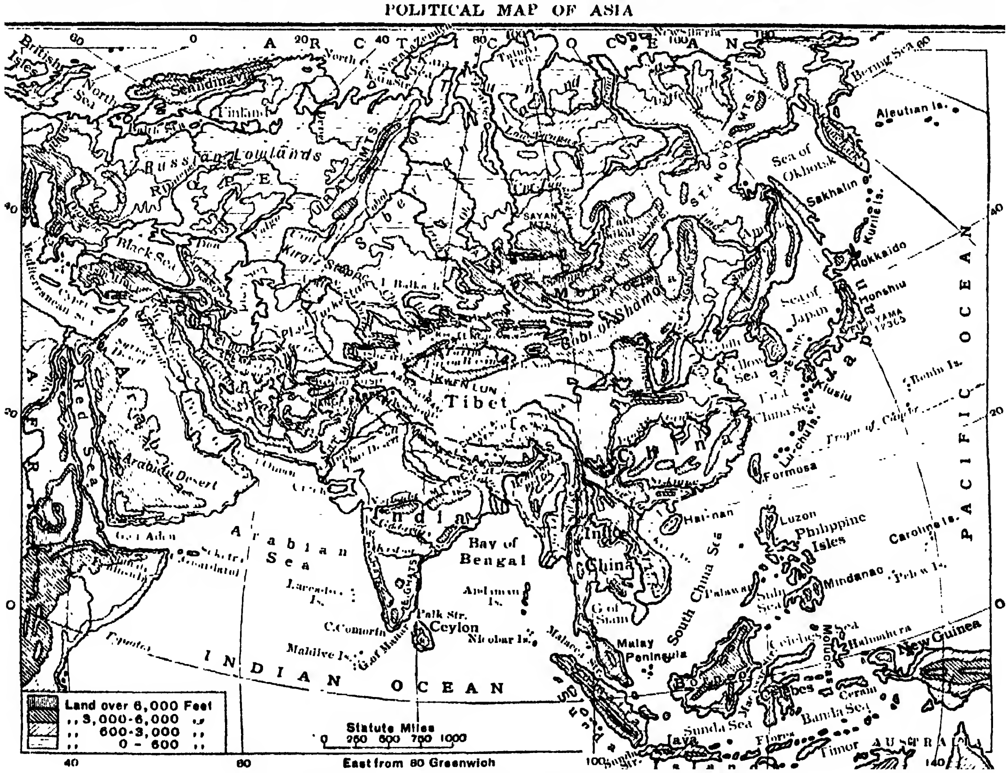
Races and Religions. Branches of the white race inhabit the Turkish, Persian, and Afghan lands and much of Russian Asia and India. The yellow or Mongolian race is predominant in China and Japan. In south-eastern Asia we find the brown or Malay race. Aboriginal peoples, not belonging to any of these, are found in many parts. The great religions of Asia are Mohammedanism, found from the Mediterranean to the Pacific; Buddhism, chiefly among the Mongolians; Hinduism in India; Confucianism in China; Shintoism in Japan; and Christianity among the Europeans, who form the minority in Russia, India, and Indo-China, though they are the dominant race politically. In most parts of Asia two or more religions exist side by side, and no exact limits can be stated for any [see page 555].

A. J. AND F. D. HERBERTSON

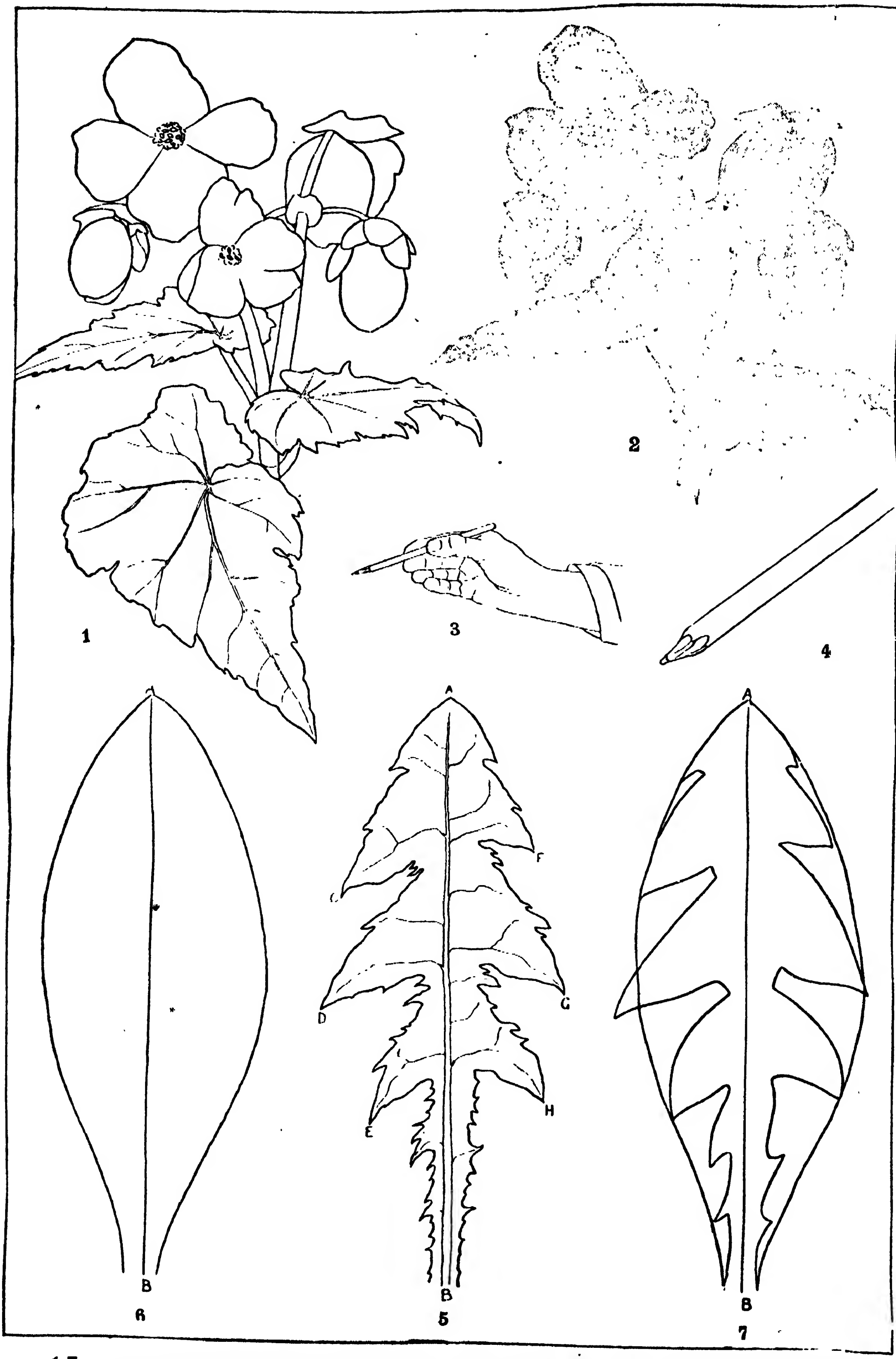
ASIA, THE GREATEST OF THE CONTINENTS



POLITICAL MAP OF ASIA



PHYSICAL MAP OF ASIA, SHOWING CONTOURS



1-7. THE DIFFERENCE BETWEEN LINE AND MASS, WITH A FIRST LESSON IN DRAWING

The First Stages of Elementary Drawing. First Principles for the Artist. The Value of Accurate Observation.

ELEMENTARY DRAWING

This course of drawing is intended for students who wish to become either artists, sculptors, designers, architects, engineers, cabinetmakers, carpenters, or craftsmen of any kind; anyone, indeed, who wishes to grasp the general principles of drawing will find the course adapted for him.

In the course is included freehand from the flat and the round, the principles of object drawing, geometrical drawing—plane, solid, and as applied to design,—brushwork, memory drawing, and light and shade. It forms a basis, therefore, upon which anyone can specialise for whatever career in the industrial arts or sciences he may wish to follow.

Drawing, the Universal Language. Drawing is a means of education, of training hand and eye; it quickens the powers of perception and gives scope to the inventive faculties. It trains the eye to accuracy, and the mind to observation, attention, comparison, reflection, and judgment. It is the handmaid of all industrial art and science, and should be cultivated to the highest degree. It is a universal language, and the shortest of shorthands. How often it is found that some simple sketch explains very much more easily and quickly than dozens, or even hundreds of words, some idea that one person wishes to convey to another! How an illustration helps to elucidate the text of a book we all know.

The term "drawing" is sometimes more particularly applied to the expression of form by line, such as is made with a pen, pencil, or other pointed instrument. But it is most important that a beginner should realise that there is no line in Nature.

Nature's objects relieve themselves to the eye as spaces or masses that are lighter or darker in tone, or of colour varying with their surroundings. Consequently, all expression of natural objects by line is a conventional rendering. Thus in **1** the form or space within the conventional line is separated from the surrounding part of the page, and suggests to us a flower, while in **2** we have the form or shape of the flower given in mass, without any line. It is merely dark relieved against light, or black varying with white. This *mass* drawing is much better for realising or suggesting the form of the flower.

Spaces and Lines. Almost every beginner thinks only of the turns and twists of the line, if drawing from a printed outline copy, or only of the edges if using an object for study. He is neglecting, of course, the most important part—the shape of the *space inside* the boundary line or edge. If we change two words in a well-known proverb, we get an excellent rule for drawing in any of its branches. This rule is—*take care of the spaces, and the lines will take care of themselves.* The eye, in other words, must be trained to see *form*, and not merely lines and edges. By and by, the student will need to see *tone* and *colour* as well.

Many pupils find it much more pleasant to make drawings of cottages, trees, or living creatures, and, unfortunately, some attempt to paint in colour, because it is so fascinating, before they know the elementary rudiments of drawing. Such misdirected efforts can only end in disaster. The work is out of proportion, the perspective is wrong, the tones and colour are false, and the performance, in fact, is lacking in most essential points. A drawing may be very neat, but if it does not give a *true* representation of the form of the object it is of no value. Again, a picture may be carefully shaded, or even admirably coloured, but if the drawing is wrong the representation must be always unsatisfactory.

FREEHAND DRAWING.

Freehand drawing is drawing done without mathematical instruments. The materials required for it are some cartridge paper, an HB or B pencil, a sharp knife, a piece of good indiarubber, and (if the paper is not in the form of a book or a block) a drawing-board, half imperial size (22 in. by 15 in.), with some drawing pins. When more advanced, pen and ink or brush may be used. All these are now so cheap that there is no excuse for working with bad materials, thus creating unnecessary difficulties to be overcome. Then, too, some *good* copies of leaves, flowers, fruit, animals, common objects, and conventional ornament can be easily obtained. Natural leaves, flowers, shells, stuffed birds, and so on may be used to advantage as copies.

The illustrations in this course are not necessarily to be used as copies by the student. They are too small, and are used here for explaining the method to be adopted in learning to draw. The student must get copies for himself, see that they are carefully graduated in difficulty, and *practise* as much as possible.

Training the Eye to See. The pencil should be sharpened as in **3**, and not as in **4**, and should be held lightly and at some distance from the point [**3**]. All sketch and block lines should be drawn lightly and freely, and not as if the purpose were to plough through the paper. A soft, grey, freely flowing line should be cultivated early, and not a hard, wiry, wobbly line.

It is necessary that the student should keep well in mind that he must train his eye to *see* correctly, and his hand to give true expression, as artistically as he can, to what he sees. It is

of little use putting down something and rubbing it out, continuing these processes perhaps half a dozen times until the drawing appears correct. There must be a definite impression in the mind before a line is drawn, and the pupil should endeavour to aim at the ideal of drawing every line correctly the *first* time. He should remember Ruskin's advice to the young man who asked how he should learn to draw. Ruskin sat down and looked for five minutes at the object for study. Then he drew one line. After another five minutes' careful observation, he drew another line, and said to the young man: "That is my advice to you on how to learn to draw." Slow, tedious work, some will say, but not so slow and tedious as learning to play the scales in music. Ruskin meant that the student must learn to *see* before he could hope to draw, and correct sight cannot be achieved by a superficial glance.

Study the Copy. This training of the eye must be persevered with assiduously. Through all stages, in order to render the pupil capable of judging more complex things in his advanced studies — such as the subtle changes of light and shade, and the beautiful variations of colour in nature— the student must persevere in the close attention to detail and training of his observation. His judgment will be more certain, and he will find more pleasure in his work. At the outset, therefore, he should carefully observe the main general proportions of the copy or object of study— how it is placed in its surroundings, its leading growth lines and masses, the peculiar growth of the plant, the pose and action of the animal. He should not trouble at first about details, but should get the main facts correctly impressed upon his mind.

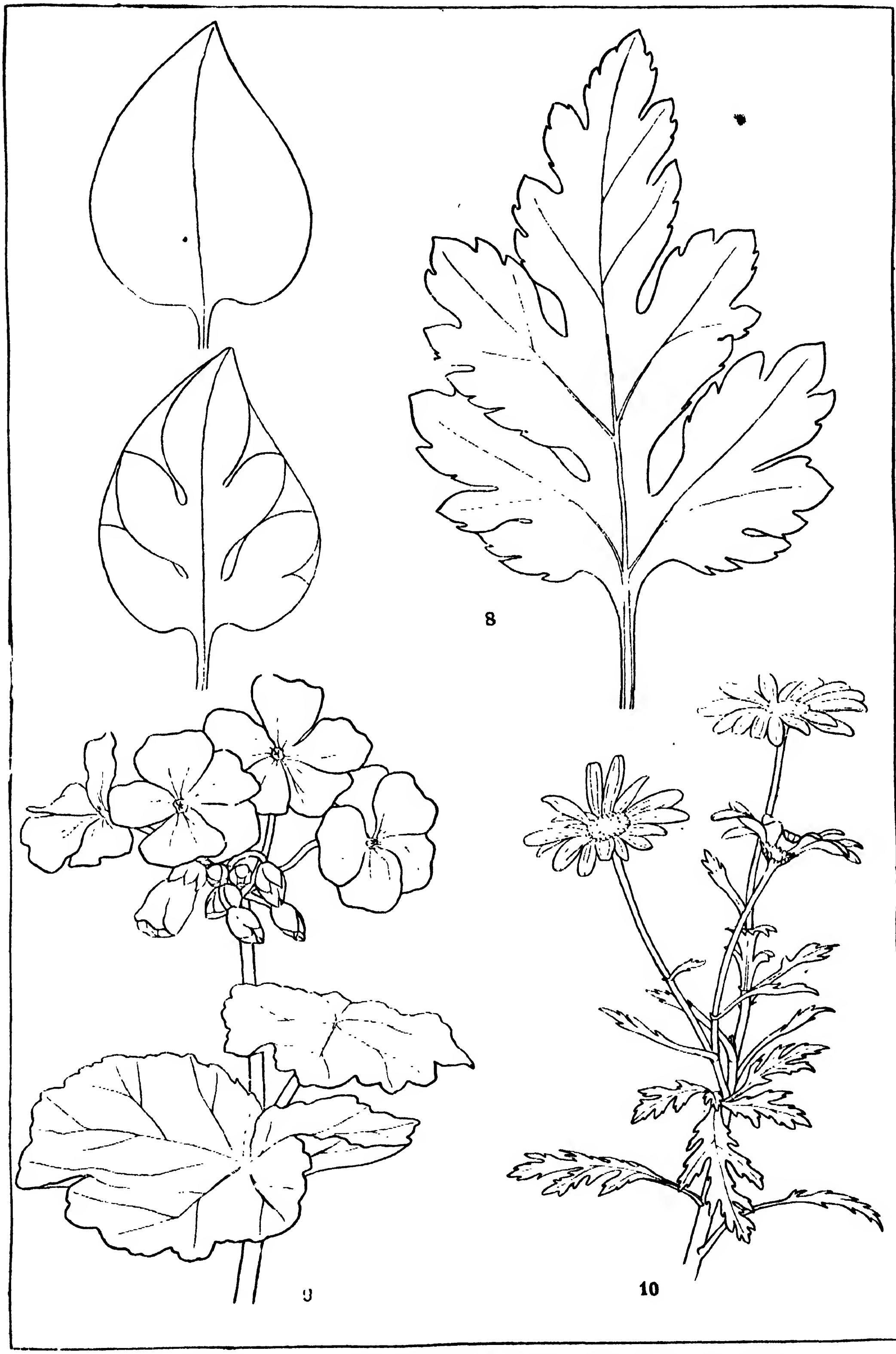
Let us take now a dandelion leaf for study [5]. Let it be pinned flat on a card or board, for the sake of more readily observing it carefully and intelligently.

Some Main Points to Note. First note the general proportion between height or length, AB, and width, DG. At first glance the student will probably think the width is considerably less than half the length, but he would have been deceived by the numerous deep serrations. If a steadily curving line is drawn almost exactly through the points A, C, D, E, and another through A, F, G, H, he will see a shape as indicated in 6. It will now be observed that the width, DG, is very little less than half the length, AB. The points D and G are about equidistant from A and B; also F is equidistant from A and G, whereas C is nearer D than to A. Again, the space CF is smaller than DG. The distance GH is about one-third of GB, but DE is more than one-third of DB, and EH is rather less than CF. The student must endeavour to judge these proportions first with the eye alone, and then test his judgment by measuring. *On no account must he measure with a pencil or ruler first.* This would be easier and quicker, and certainly the result would be quite correct, but he must remember that he must train the eye to *see*. Judgment with the eye alone will, of course, be more or less inaccurate at first, and the work will seem slow and tedious, but this method must be persevered with if true progress is to be made. Each time the student will succeed more and more, until he will become surprised by the way in which he can at once *see* the true proportions.


A JAPANESE WASH DRAWING

Features to Observe. Next direct the attention to the three peculiarly shaped lobes on each side, with the deep serrations between, noticing that one of the three lobes on each side is the largest, and a subtle gradation in the size of the others. The downward direction of the characteristically shaped "teeth," from which the plant gets its name (dent de lion), the gradually thickening midrib, with its secondary branching veins, and the way in which they grow from it, should also be noted. Another important feature is the tendency of the side veins to run down toward the base of the leaf, as generally happens. These veins are also nearer the lower edge of each lobe. This thorough investigation shows what a great deal would be missed in a superficial glance, and that there is method and regularity underlying apparently irregular forms. Observe most carefully, also, the decorative effect of the whole leaf, and aim to reproduce it.

Having now stored the mind with many facts, begin by drawing a central line AB, and the two curved lines [6]—*block* lines, they are called—rigidly keeping the relative proportion previously observed. Block in the large lobes in their true proportions, carefully noting how



8-10 SUGGESTED STUDIES IN CHRYSANTHEMUM LEAF, GERANIUM, AND MARGUERITE

far the main serrations go in towards the mid-rib, and leave out the smaller serrations [7]. Now put in the largest secondary veins, keeping all lines faint yet visible, so that comparison can be made between the drawing and the leaf, and discrepancies corrected. Alterations can always be made more easily and quickly at this stage, with only simple block lines to deal with, than when the details are filled in. It would be best not to sketch in details at all now, but to draw them direct in the finishing stage, when they are more likely to have the desired expression which rarely or never comes at first.

Finishing. If all appears so far correct, partially rub out block lines, and finish with a neat, fluent, and expressive line, not necessarily one that is all the same thickness. The lines for the edges might be stronger than those for the veins. There might, in fact, be varying degrees of thickness used at discretion. Do not forget in this finishing stage very closely to observe the natural leaf, in order to get true representation, and be especially careful to note the characteristic shape of teeth and serrations. The finished drawing should now be like **5** in proportion and shape of details, but the line should be more expressive and more artistic than can be rendered by a printed line. A really artistic hand-drawn line must always be more beautiful and expressive than a printed one, for there cannot well be artistic feeling in a machine.

The student should get other leaves or flowers, such as **8**, **9**, and **10**, and go through the same process of observation in every case before beginning to draw, always trying to develop his perceptive faculties.

For further explanation of the method of learning to draw we will take a copy like **11**. This is absolutely symmetrical, and is a piece of ornament founded on the honeysuckle (*anthemion*) and acanthus leaf. Observe that, although the design is conventional, there is suggested a system of growth and radiation from point B, and that the design has a sense of unity, vigour, and stability, as well as a beautiful and subtle gradation in the size of subordinate parts. Though certain forms are repeated many times, there is no suggestion of monotony. This study of the artistic side of a copy or object must be cultivated as soon as possible, not merely to add interest to the work but to increase the powers of perceiving the beautiful.

The Straight Line. On the practical side is an upper (*anthemion*) and a lower (*acanthus*) portion. The greatest width, CD, is very nearly four-fifths of the height AB, and the spaces HK, KF, FL, etc., are nearly equal. Draw first the central line AB, say, about eight or nine inches long, so as to make a good-sized drawing. It is much better not to draw on a small scale, because freedom of pencil movement should be cultivated, and a better exercise in judging proportion can be made with a drawing of moderate scale. Do not rule construction lines, but practise pure freehand drawing. When drawing the line AB be careful to keep it quite vertical, otherwise the drawing, when finished, will appear to be falling over, thus destroying the stability observed in the copy.

One of our living artists has said that not more than one person in a hundred can draw upright lines freehand. This is quite true among beginners in drawing, because, through want of thought, they do not sit properly in front of their drawing paper, or they unconsciously turn the paper cornerwise. The uprightness of the leading growth line AB ought to be judged at the start by noticing whether it is parallel to the right and left-hand edges of the paper.

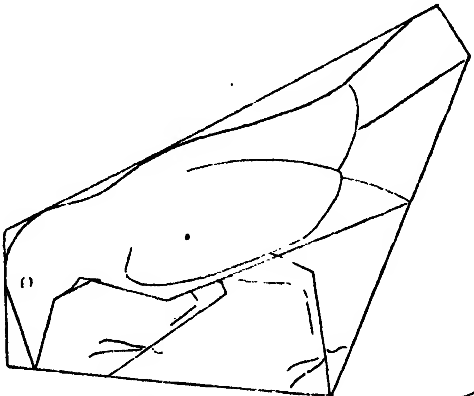
Having drawn AB correctly, do not draw a lot of horizontal lines, say, HN, KO, FG, etc., which would be getting merely mechanical accuracy and confusing the work with unnecessary lines. Determine the greatest width CD by lightly marking where the points C and D should be, being careful as to how far down they must come. Next mark the position of F and G, observing that the space FG is four-fifths of CD, and about midway between A and E. Then draw lightly and freely the block lines of the large masses indicated in **12**. Afterwards draw the leading growth lines, and the secondary block lines [**13**], observing carefully all the time the relative proportions of the spaces between them.

At this stage, again, compare the sketch with the original, and correct any mistakes. Nearly rub out the construction lines, note the peculiar shape of the serrations of the acanthus leaf, and the tangential junction of neighbouring lines of honeysuckle, and finish with a good fluent line.

The Help of Museums. The student should continue practising similar copies graduated in difficulty. He might also study from casts of ornament, or from real sculpture in relief, or from woodcarving. Many fine specimens are found in museums, churches, and any interesting old buildings. A sketch-book should be carried in readiness for sketching any rare and beautiful piece of ornament, which may be useful for reference and give facility for practice.

Almost everybody has a wish to be able to draw beasts and birds, and by this time the student should be able to draw them from good flat copies, or better still, from the stuffed examples in museums, which make excellent studies if placed so as to get a profile view; otherwise placed there is too much difficulty at first with foreshortening, a subject we discuss in dealing with object drawing. The method to follow in such studies is similar to that to be pursued in securing general proportion of masses and block lines, although the latter should be more frequently *straight* ones. The pupil, however, must assiduously seek for the pose and action of the creature.

A New Field for Perception. Take, for example, a study of the crow, as in **14**. Observe the general proportions and note the pose and action of the bird—that it is bending down as if to peck up something, its legs in a characteristic attitude to enable it to do so, one stretched forward and the other partly raised



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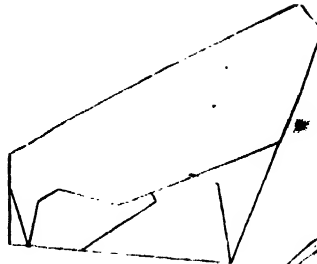

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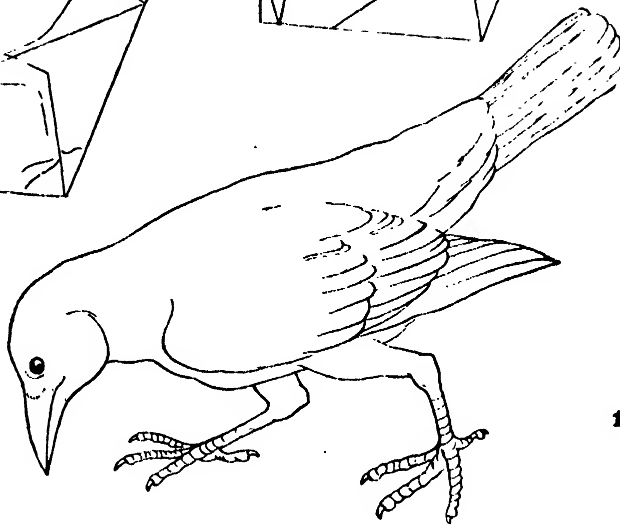

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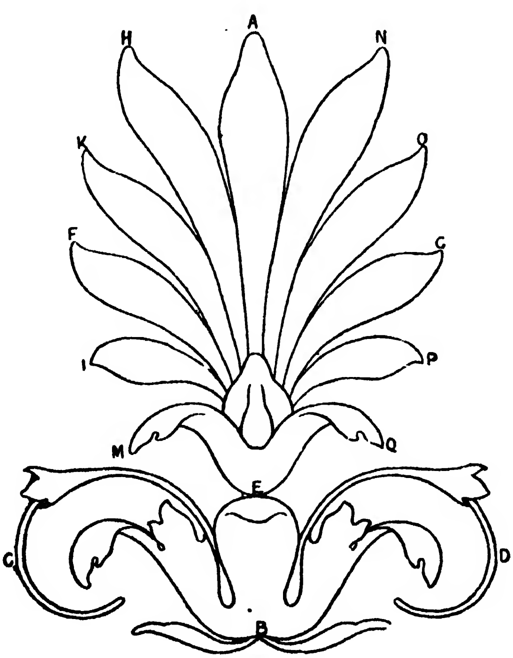

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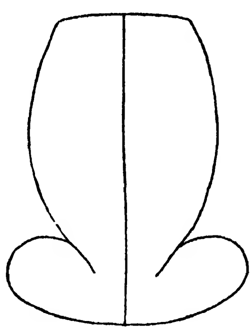

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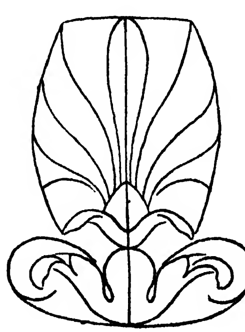

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11-16. ORNAMENTAL DRAWING—STUDIES OF A CROW, HONEYSUCKLE, AND ACANTHUS

as if the bird were stepping forward. There is time to study all these things with the printed copy before us, but in the study of the living creature the pose or action is momentary, and only keen and rapid observation is of any avail to secure a true representation.

This opens a new field in which the student should continue the development of his faculties of perception. Let him study all kinds of living creatures in action, and either mentally or in his sketch-book—or, better still, in both—jot down each main characteristic line expressing the action.

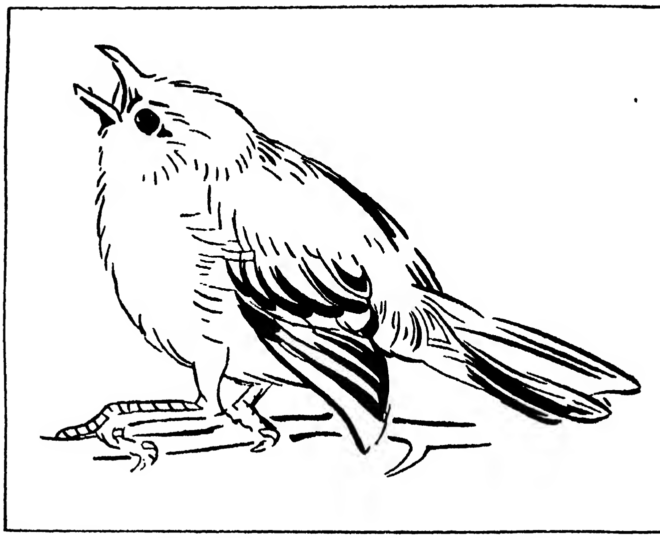
Drawing from Life. The first block lines for the study of the crow should be as in **15**, the chief observations concerning the relative proportions, pose and action. It will be seen that these block lines are chiefly straight; this is to obtain more vigour, real expression, and a suggestion of the anatomy of the bird in the finished drawing.

It will, moreover, enable the student to develop a good system, by which, when he arrives at a more advanced stage, he can draw the human figure or any living creature in any position. Proceed with the next stage as indicated in **16**, clean up with the rubber, and finally draw with as expressive and artistic a line as possible, putting in any necessary details direct. The lines in such a study, as in studies of leaves and flowers, need not be all of one thickness, but should vary, giving strength to those lines which need it. A single stroke, even, need not be of the same thickness throughout. The lines, too, may be more broken, yet in such a way that there is no confusion, but the true representation of form or mass.

Well-drawn representations of butterflies' shells, and fish will make good copies, but it would be much better if the objects themselves could be obtained and used as studies.

Pen and Ink. As considerable progress in drawing with lead pencil ought now to have been made, it will be useful to make freehand studies with pen and ink. The materials required can be obtained at such little cost, and of such good manufacture, that the student need only be careful in the selection of them, in order to provide himself with very satisfactory materials. Artists' black or liquid Indian ink are the best inks, and the pen should be flexible, so that varying thicknesses of lines may be obtained easily and quickly. As regards paper, cartridge has too soft a surface to give very good results. It is best to purchase some *hot pressed* Whatman's or Old Water Colour Society's paper, or, better still, some Bristol boards.

In beginning to draw, sketch first with lead pencil the leading growth and block lines in true proportion, and then, without any preliminary sketching of details in pencil, proceed to finish with pen and ink, holding the pen so that perfect freedom of movement in any direction, and different thicknesses of lines, may easily be obtained. Make all the lines as expressive as possible. The student should often study the pen-and-ink work of celebrated men. He will often find good examples in the illustrations of books—by Walter Crane, Sir John Tenniel, and many other modern artists. Among the older masters, Dürer and Holbein may be mentioned, and, although their work is not all pure pen-and-ink drawing, much may be learnt from them about expression of line.



A JAPANESE BRUSH DRAWING OF A BIRD

It is good practice to draw direct with pen and ink without *any* pencil construction lines. This still further develops the student's powers of perception, because, knowing that he cannot easily rub out ink lines, he is more careful to form a definite impression before drawing a single line.

Line drawing with a brush and Indian ink, sepia, is another good exercise. The brush is so flexible that many things can be expressed by it better than with pen or pencil. The brush should be a sable " writer," and not too small. To learn what may be done with a brush in line drawing, the pupil should study the many fine examples of Japanese work, in which great charm and skill are displayed. [Examples are given on this page and on page 2270.]

If the student has steadily persevered, in spite of difficulties and disappointments, through the course we have taken together, he will have realised how exceedingly important it is to follow the advice about an intelligent, searching observation of the whole object before he begins to draw. He must have in his mind an exact and clear impression, before he can hope to transfer truth to paper. WILLIAM R. COPE

The Voice and its Apparatus. Vocalisation and Speech Production. How Best to Use the Voice. Public Speaking.

THE HUMAN VOICE

Turning now to the important faculty of speech, we will try, very briefly, to describe first the mechanical apparatus of the voice, then the production of air-currents, and the vocalisation and the articulation that produce speech, giving also a few hints on the use and management of the voice.

Three Stages. The whole process culminating in speech may be clearly divided into three parts. First, the production of the needed current and volume of air; next, the production of sound; and, thirdly, the moulding of this sound into words. For the first the lungs are needed; for the second, the larynx; and for the third, the mouth—*i.e.*, tongue, teeth, and lips.

The two former may be roughly compared to the common harmonium, where sound is produced by the wind being forced up from the air-chest below through the vibrating reeds above. There is, however, in the harmonium no further apparatus to form these sounds into words, and thus to correspond to the mouth. Moreover, for all the notes of the different octaves (say, three, which is the average compass of the human voice), no fewer than 36 separate reeds are needed, whereas for the same compass in the human organ but one set of reeds is used, as there is a mechanism to alter it to all the different tones required.

Construction of the Larynx. The larynx, or voice-box, is situated, as we have said, in the neck, and leads from the back of the mouth to the top of the trachea, which brings the air from the two lungs below. It is an open tube with a lid, and is about 3 in. long. The walls and lid are composed of cartilages. The largest is that forming the centre part of the tube, the *thyroid*, and is the least movable, the *epiglottis*, or lid, and other cartilages, to which are attached numerous muscles, being freely movable in various directions.

Across the middle of the tube, from the front to the back, are stretched two flat bands, fixed together at the front, but capable of being separated behind, where they are attached to two movable cartilages called *arytenoid*. When these two bands are brought together, they form a sort of flat drumhead, or septum, that shuts off the upper from the lower half of the larynx so perfectly that even a drop of water cannot pass through, while, on the other hand, they can be separated so widely that the opening is triangular, or, rather, the shape of a spearhead, the point being forward and the broad part backward. These bands are the true vocal cords, and the air that passes through the narrow chink between them is thrown into ripples or air-waves by the vibration of their edges; and these waves, when they strike on the ear, produce sound. The two vocal cords in the larynx, therefore, by their vibration, are the true voice or sound producers in the higher animals.

The Vocal Cords. These are composed of elastic, muscular, and fibrous tissue, and are of a glistening white appearance, as may be clearly seen by a small mirror placed at an angle in the mouth, and called the laryngoscope.

Above them, on either side, the walls of the larynx make a sort of pouch, the upper parts of which, bulging into the larynx, form two folds above the true vocal cords, and, as they slightly resemble them, are called the false vocal cords. They act, to a certain extent, as dampers or deadeners of sound, though they never actually touch the cords, while the pouch between secretes a considerable amount of glairy fluid which serves to lubricate the cords and keep them from getting dry.

Action of the Tongue. At the top the lid, or epiglottis, of the larynx, which is hinged in front and folds down backwards over its mouth, is fixed to the under side of the back of the tongue in such a way that whenever the tongue is carried forward it is raised and opened, and when the tongue is carried back, as with food, it shuts tightly down, allowing all food and drink to pass over it and down the gullet behind. It closes over the larynx so completely that not a drop of water can pass down into the windpipe. In breathing, as well as in speaking or singing, it is, of course, always open, while in swallowing it is tightly shut. We cannot, therefore, breathe while we swallow, nor swallow while we breathe. Such, then, briefly, is the construction of the larynx. It only remains for us to add that the whole larynx, as well as the windpipe, lung tubes, and back of the throat, are lined with ciliated epithelium in such a way as to pass up into the mouth any particles that may settle upon them. In nearly all affections of the air passage this membrane is more or less destroyed for the time being.

Voice Production. The voice is produced by the rushing of the air through the narrow chink between the bands, or "cords," which can be plainly seen by anyone who can use the laryngoscope. On the other hand, these bands can be seen widely open and far apart during quiet respiration.

The narrower the chink, the greater the pressure of the air as it passes through, and the higher the note produced. By the varying tension and approximation of these cords a range of sound extending on an average to three octaves can be formed.

In the adult male the cords are nearly one-third longer than in the adult female.

An imitation of the voice apparatus can be

made by stretching across the top of a glass tube two bands of indiarubber close together. If these are blown through with a certain force, a sound will be emitted, higher or lower, according to the tension.

The action of the cords as well as the closure of the top of the larynx being regulated unconsciously, it would appear at first sight that we cannot do much voluntarily in arranging the production of the voice. Such, however, is far from being the case. We can, in the first place, see that the delicate structures are not in any way injured by our carelessness; and, secondly, we can, by practice, regulate to an exact nicety the action of the cords so as to produce instantaneously the exact sound required.

Breathing through the Nose. A great point in the care of the larynx is to breathe through the nose, and not through the mouth. The mouth is made for expiration, specially in speech and vocalisation, but not for inspiration, for which the nose is specially constructed. The mouth should be kept shut, but it is still possible to breathe through the nose with the mouth wide open when once the habit is acquired; and, on the other hand, there are certain passages in singing where, owing to the elevation of the soft palate, breathing through the mouth is necessary. If the nose cannot be or is not regularly used as "the" respiratory passage, a doctor should be consulted at once, as there is something blocking the natural passage—enlarged tonsils, adenoid growths, or some malformation.

Care of the Voice. Sudden changes of temperature are extremely injurious to the vocal cords, especially after prolonged use. Great care should be taken by speakers and singers against chills or draughts of cold air after using the voice, and also after leaving close or heated rooms. A loose muffler over the mouth and nose when first going out is a wise precaution. Air too dry or too damp is also injurious in public speaking. Air, again, overladen with dust or smoke or fog is most injurious to the vocal organs, which must suffer, if the voice be much used under such circumstances.

No loud speaking or singing should be persevered in if the throat be at all sore or relaxed, or if there be a severe cold in the head. Neglect of this is one of the common causes of clergyman's sore throat. Of course, as we have already said, any definite chest affection, such as bronchitis, precludes all public speaking.

Management of Expiration. So far, we have spoken of inspiration in connection with the larynx; let us now consider, for a moment, expiration.

We have already said this is to be carefully economised and none of the air wasted. The exit of the air can be retarded by the approximation of the vocal cords. But this, of course, raises the pitch of the voice or note. The secret of keeping at the same note and yet retarding the exit of the air is by the approximation of the false vocal cords above the true. This can only be done, as we say, instinctively, or, rather, unconsciously, by practice; and the retardation of the expiration, so as only to use what air is needed and keep some well in hand, is one of the secrets of ease in speaking and singing.

There should be no strain in singing or speech. Loudness is not necessary for force or beauty, but a good volume of air is.

Pitch. The pitch in speaking is of great importance, not only to the speaker but to the hearers. With regard to the latter, it is not too much to say that the conveyance of thought by speech depends not only on the words, but the tone and pitch. It is wonderful what a power to sway thought a well-pitched and modulated voice possesses. Of course, in singing, the pitch is always considered; but in speaking this is rarely done, though its importance to the speaker is as great as to his audience. A wrong pitch strains the voice and the vocal cords. We all have for speaking what may be termed a natural pitch of voice, just as we have a natural pace for walking, and that is the pace or pitch which we can use with the greatest ease and without strain.

SUPERIOR APERTURE OF LARYNX
Showing the glottis during emission of a high note
1. Root of tongue 2. Epiglottis 3. Posterior wall of pharynx 4. Rima glottidis 5. True vocal cords 6. False vocal cords

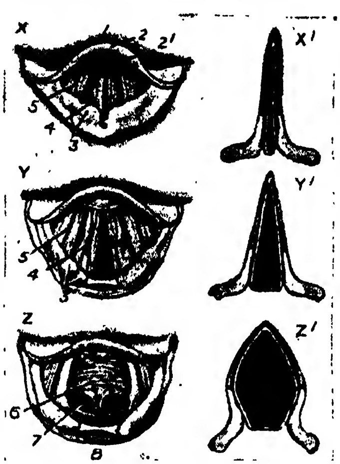
Public Speaking. There can be no doubt that absolute ignorance of the simple laws of voice production still prevails even amongst our most constant speakers, and it is not much to the credit of the twentieth century that amongst large bodies of men such as clergy, barristers, etc., whose living depends very largely on their voice, many should fall out of the ranks altogether, or, at any rate, suffer needless pain and misery for want of a few lessons on this most useful art. At Athens every student was taught how to speak properly and to use the voice with ease and effect, as being essential to health, quite apart from its special value to speakers.

We have little doubt that for a child of a consumptive tendency there could not be a more healthful and curative—or, rather, preventive—exercise than a thorough course of instruction in voice production by a competent teacher. At any rate, it is beyond dispute that such a course should form an integral part of the education of every public speaker. This is especially the case with the clergy. They are the class whose vocal organs are most severely tried. The buildings in which they speak are often far more trying than concert-halls or lecture-rooms, which are built to carry sound. The vaulted roof, the long aisles, the cold, vault-like air at the early morning service, the close stuffiness of the crowded evening church, the incurable and ever

present draughts, are all bad. Worse still is the "pulpit voice," artificial and strained; it is bad for the larynx and throat, and wears them out, while a natural voice would continue in full vigour and tone.

Articulation. Passing on now to the third part of speech production, that of articulation in the throat and mouth, we may point out that it consists of at least two processes. First, the moulding or shaping of the air-vessel into the various vowel sounds by the opening and closing of the throat, "ah" being sounded when the throat is open to its widest, and "oo" when it is most nearly closed, the other sounds falling in between. Secondly, the cutting off of these sound waves into different lengths, to form words or syllables, by means of what are called consonants, which are closures and sudden openings that first stop and then allow of the passage of air and of the vowel sound by the closure of the lips as in "m," or with the tongue against the front of the hard palate and teeth as in "s," or against the front of the hard palate as in "t," only the opening of the fauces as in "k" or "g," and so on—each consonant giving a characteristic "click" or other sound of opening.

Vowels alone are true vocal sounds that can be prolonged as long as the mouth remains in the same shape, and as long as the current of air continues, the pitch being, of course, determined by the vocal cords.



THE LARYNX AND GLOTTIS

X and X'. Nearly closed for highest notes Y and Y'. Open for quiet breathing Z and Z'. Open very wide for gaping 1. Base of tongue 2. Tip of epiglottis 2'. Thyroid cartilage 3. Triangular cartilage to which vocal cords (4.) are fixed 5. False vocal cords 6. Inside of larynx 7. Wind pipe 8. Point of gullet

It is all important to enunciate and articulate clearly; all the vowel and consonant sounds should, therefore, be carefully practised with the greatest accuracy; such practice, like all other vocal exercises, is best done before a mirror.

The Aspirate. The letter "h" is often an insuperable difficulty. It is, perhaps, best overcome by expiring forcibly against a window-pane and adding some syllable such as "at" or "ot" to the expiration. The expiration is then gradually shortened till it becomes "hat" or "hot."

Another difficulty is stammering or stuttering. In minor cases this is cured by slow, deliberate formation of each word until the habit is broken. More severe cases require special treatment, which is now admirably conducted. Nearly all are curable. "Take care of the consonants, and the vowels will take care of themselves."

For proper speech the teeth should be complete in number and kept in good order. If the tongue is swollen or sore, or the tonsils enlarged, speech is difficult. In the latter case, enlargement of the tonsils, the removal of the same portion under surgical advice is of great value. The throat also must be in good order.

Effect of Food and Drink. Food and drink greatly affect the condition of the lining membrane, both of the mouth and throat, and indirectly of the vocal cords. First and foremost is the abuse of alcohol. No one who speaks or sings much can indulge freely in alcohol with impunity, while in many even a small quantity is prejudicial, as the effect on the stomach and pharynx is distinctly bad. The very voice of the habitual drunkard speaks of the ravages caused by alcohol. In small doses, well diluted and taken with food, alcohol is not itself harmful to the voice organs when they are in health, but if they are diseased even a very small quantity may do harm. Strong tobacco, especially in the form of cigarettes, is injurious to the voice.

Much hot tea, in the same way acting on the digestion, is not beneficial to the voice; coffee or cocoa, or cold tea, especially if not too strong, are not harmful. It is not well to use the voice publicly at any length sooner than two hours after a full meal.

Two great practical defects in speaking and singing may be noticed. One is that the mouth is often not sufficiently opened, and the other is that the voice is often dropped two or three or more tones in pitch towards the end of a sentence so that the words are quite lost at a little distance.

The secret of easy public speaking is the understanding of respiration so as to retard it at will, the use of the right pitch, modulated tone, and the natural voice, avoiding a forced or artificial voice, monotones, and all strain. Speak in an erect position, eat suitable food, and retain as far as possible good general health and sound nerves.

The "British Medical Journal" enumerates four special points on the right use of the voice:

1. Thorough control of the motive power of the voice and breath.
2. A proper attack of tone.
3. The education of the resonant cavities of speech.
4. The right pitch.

With this consideration of the organs of the senses we reach the conclusion of our survey of the human being from the physiological point of view; and we shall now turn to a subject of vital concern in all our lives—the prevention of disease and the maintenance of the body in health.

A. T. SCHOFIELD

PHYSIOLOGY CONCLUDED

The Best Breeds of Goats. The Great Value of Goat's Milk. Feeding. Goat-farming for Profit.

GOAT-REARING

Goats are less quiet and submissive than sheep are when under domestication, and their habits are more erratic and more independent. Although typically mountain animals, and naturally living in flocks, they do not mind being separated from their fellows, and love, when possible, a roaming life and opportunities of climbing to great heights among rocks. They are very sociable when living with man, and show little fear of their owners.

"The Poor Man's Cow." For centuries the goat was largely domesticated in the British Isles, but with the extension of sheep and other improvements in agricultural practice the numbers gradually declined, and it is only of recent years that the economic importance of "the poor man's cow"—especially for the working classes, who often are unable to obtain a supply of wholesome milk for their children—has been again recognised.

Besides providing a supply of nutritious milk, which is specially adapted to the requirements of children and invalids, other parts of the animal may be used for various purposes. Thus in certain countries the hair is clipped from the body and made into coarse cloth for tents and the like; the skin is very valuable for the manufacture of leather, and provides the fine morocco leather of commerce; the skin of the kid is further in great demand for making gloves of the finest quality.

There is a prejudice in the United Kingdom against using the flesh of the goat for food; and although in the case of older animals the flesh is somewhat tough, the kid is as delicate and digestible as lamb.

Breeds of Goats. The goat is very hardy and can stand great vicissitudes of climate, although it is rather liable to suffer from exposure to extreme cold. Extending as it does throughout so many countries and climates, it is not surprising that we find great variations of form and character in the several domestic breeds in different parts of the world. Although horns are generally present, in certain breeds they disappear in one or both sexes. The hair in some cases is long, in others short. The beard in some breeds is very prominent, and in others it is hardly noticeable. The colour also may be any shade from pure white to black, or patches of these two colours, brown sometimes appearing. The size and form of the body may also vary considerably.

As in the case of pigs, the common goats in the United Kingdom have latterly been largely crossed with foreign blood, and the aboriginal breeds are therefore being gradually superseded by animals for the most part of foreign ancestry. With regard to the foreign breeds, more care has been bestowed by the breeders in the past to develop their useful qualities than in the case of the British native varieties, and consequently the former are able to introduce many excellent qualities when crossed with British stock, resulting in increase in size, improvement in milking, and other desirable features.

English and Irish Goats. The chief breeds or crosses found in the British Isles are the following.

English Goat. This is characterised by a short-haired and thick coat. The colours may be black, white, grey, or of a brownish tint. The points of what is known as the English do not seem to be very well fixed, and Welsh and Irish blood are often apparent. Horns and a beard appear in both sexes.

Irish Goat. This animal differs from the English in having a long-haired and somewhat shaggy coat. The colours are white or pied, sometimes running into a red. Both male and female possess horns which are large in size, corrugated, and pointed.

The Swiss Breeds. The Swiss varieties include the following.

Toggenburg. A hornless variety from the canton of St. Gall, in Switzerland. It is the most appreciated of the Swiss varieties in the United Kingdom, and has been largely used for crossing.

Saanen. This white, hornless breed is much esteemed for its milking properties.

Cross-bred Goats. The chief crosses are:

Anglo-Nubian. This is obtained by crossing with the Nubian, a breed with pendulous ears and short, black, twisted horns. This cross is considered one of the best breeds now in the British Isles. It may be black, white, brown and black, or any mixture of these colours. The hanging ears of the African ancestor are generally apparent.

Anglo-Toggenburg. This is a cross between the Toggenburg and the English.

Both Anglo-Toggenburg-Nubians and Anglo-Toggenburg-Anglo-Nubians are also to be met with in the United Kingdom.

The Advantages and Value of Goat's Milk. The principal object for which goats are kept in the United Kingdom is for the production of milk, and much attention has been paid to improving the milking powers of the principal varietes. The introduction of classes for milch goats into agricultural shows has had a beneficial effect, and good milking strains are being evolved and careful pail-records made.

The chief advantages claimed for goat's milk as compared with that from the cow are: (*a*) The milk is of better quality, sometimes containing nearly twice as much butter fat, and it is also very digestible; (*b*) the goat is practically immune from tuberculosis, and therefore there is no

fear of contamination in the milk supply; (*c*) the milk is produced under the most cleanly conditions, as the goat does not get fouled with manure as in the case of the cow, and the animal can also be easily washed. The figures in the table taken from König are of interest, and show the superior quality of goat's milk as compared with human or cow's milk.

PURE-BRED ENGLISH GOAT

COMPARATIVE FIGURES SHOWING AVERAGE COMPOSITION OF MILK

	Human	Cow	Goat
Water	87·11	87·17	85·71
Fat	3·78	3·69	4·78
Proteids (flesh-formers) ..	2·29	3·55	4·29
Milk sugar	6·21	4·88	4·46
Mineral matter	0·31	0·71	0·76
	100·00	100·00	100·00
Total Solids	12·59	12·83	14·29

The milk seems to be of special value for delicate infants, and in some countries babies are fed directly from goats, their mouths being applied to the washed teats so that they are able to suck for themselves. The results obtained by this method seem to be all that can be desired as far as the health and thriving of the children are concerned.

Milk Yield. A good goat of a milking strain may be expected to yield two quarts a day after the second kidding. A few in the United Kingdom have been known to yield a gallon a day. The yield, of course, gradually diminishes as time goes on, till the nanny is dry. A goat should give sixty gallons in the year, and an exceptionally good one may do up to one hundred gallons, but this is very rare. In purchasing females it is wise to have a guarantee that they will give at least three pints a day at kidding.

Breeding. The natural time for goats to breed is once a year, in the spring. With the introduction of foreign blood, however, it is possible to get them to breed at other periods, so that a continuous milk supply can be obtained all the year round. Generally, two kids, though occasionally three or four, are produced at a birth. For purposes of milking, most up-to-date goatkeepers prefer the nannies to stand on a low bench, with their heads in a sort of guillotine.

Feeding. As regards feeding, goats are very capricious in the selection of their food, and do not graze steadily, as do sheep, on the richer lowland pastures, but prefer moving about and cropping a variety of herbage as fancy directs them. Moreover, they are very fond of gnawing bark and, when they have a free range, of devouring the tender shoots of shrubs, trees, and hedges. They are therefore often looked on as an unmitigated nuisance in highly cultivated districts, especially where much fruit is grown.

During stall feeding in winter, goats are apt to be wasteful, and hay and other food will be picked over and trampled under foot unless care be taken to prevent it. It must be remembered that a variety in the dietary is essential if we wish to keep goats healthy. In summer, grass in conjunction with cut green fodder and waste from the garden, and perhaps a small feed of oats at milking time, will be sufficient. During winter, hay, rough fodder, roots, and an allowance of corn in the form of oats or bran are the usual feeding stuffs employed.

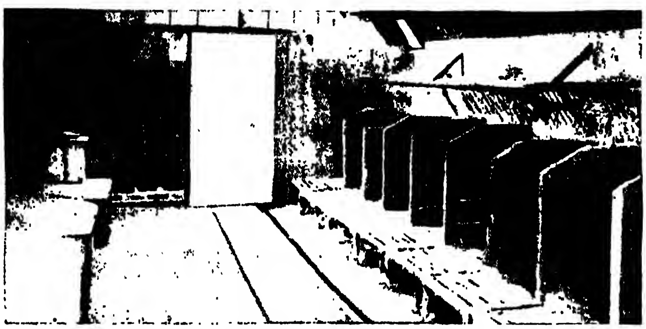
For the cottager, browsing by the roadside will be found a wholesome and economical means of feeding his goats. Tethering is a method adopted in some quarters, whereby the goat is attached by a collar and chain to an iron peg fixed securely in the ground, and this can be shifted from time to time so as to crop the area evenly. In the neighbourhood of towns, goats are often kept entirely in stables with exercise yards attached, their food, in the form of cut fodder and garden waste, being carried to them. This plan is followed in many cases with most excellent results. Goats are supposed to be able to eat with impunity certain plants poisonous to other animals, but it is wise to keep them away from yew, privet berries, rhododendrons, laburnum pods, and laurel, as fatal results have been known

PURE-BRED TOGGENBURG HE-GOAT

when these plants have been consumed in any quantities, especially when withered. Sudden changes in diet should be avoided.

Value to Small-holder and Cottager. With the increase in the number of small-holdings and the extension of the garden ground attached to cottages, there seems every inducement for an increase in the number of goats kept. The goat is small in size, adapts itself very easily to its surroundings, and is not at all particular as regards food, provided it can get sufficient variety. It does not care for grass from a pasture alone, but prefers a mixture of herbage such as is found along the roadside and in odd places, and thus it can profitably be made use of as a scavenger. It will also make use of, and turn to good account, garden refuse which would otherwise be wasted.

Although a prejudice exists in some quarters against the flavour of goat's milk, and people who are not accustomed to its use are suspicious of it at first, where scrupulous cleanliness is observed in its production a taste for the somewhat strong flavour is soon acquired, and often much appreciated. Moreover, where the richness of its quality is known and the value of its feeding properties recognised, a higher price can be obtained for it when retailed than for cow's milk



A HYGIENIC GOAT-STABLE
The frames on which the animals stand are removable for cleaning. Note also the open gutter.

Profit from Goats. Obviously, goats can be kept at a cheaper rate in summer than in winter. The estimates of several goatkeepers put the cost of keep per week all the year round at from 6d. to 1s., although this

TOGGENBURG SHE-GOAT

may be exceeded in the vicinity of towns, where most of the food has to be purchased. It is also of importance to remember that the labour involved is relatively small, and adults need not be employed for the purpose. This naturally commends the goat to small-holders. Housing

A NUBIAN GOAT

is, of course, a comparatively simple affair and—provided sanitary precautions are duly observed—very primitive accommodation will suffice. Even for one of the larger small-holdings, the purchase of a cow involves a serious outlay, and after a time the annual depreciation will cause anxiety, to say nothing of untimely death and the necessity for notification under Tuberculosis Order. Goats afford a solution of such difficulties.

The following seems to be a fair statement of the yearly cost of keeping and the returns that may reasonably be expected from a good goat.

OUTLAY

	£	s.	d.
Annual depreciation on goat costing £3, with interest	0	15	0
Keep, 52 weeks at 1s. a week	2	12	0
Labour and housing	0	15	0
	£4	2	0

INCOME

	£	s.	d.
80 gallons of milk @ 1s. 4d. a gallon	5	6	8

Balance as profit, £1 4s. 8d.

The goat, therefore, must be looked on rather for the supply of milk for home use, or for sale where a private connection has been worked up locally, than as a meat producer. This being the case, the cultivation of the goat may prove of great value to the working classes in the United Kingdom.

DRYSDALE TURNER

The Root Question of Chemistry. Physical Chemistry. The Atomic Theory is not Destroyed. Analysis of the Atom.

THE REALITY OF THE ATOM

OUR study of radium has prepared us in some measure to consider anew a question which is of far greater importance than any fact about radium as such, but a question to which the study of radium is gradually providing an answer. It may be said, perhaps, that the root question of chemistry is the nature of matter. That is also a question for the physicist, though not his root question. The physicist is at least as much concerned with the impalpable something we call *energy* as with matter, while the chemist concerns himself with energy only in so far as he needs to do so in order to understand the changes which matter undergoes, changes which, for convenience, we distinguish as chemical.

All Things are One. But it is now far too late in the day to speak or think as if there were any fundamental line of demarcation between Physics and Chemistry. Nowadays, a man may call himself a chemist or a physicist, but he will be of exceedingly small importance as either unless he be both. Endless instances might be accumulated that serve to show how closely the sister sciences are interconnected. It is probably safe for the present writer to assume that there is no reader of this course who is not also a reader of the course on PHYSICS. We may make distinctions, for convenience, between them, but ultimately the two sciences are one.

Unity of Chemistry and Physics. There is no correspondence in nature—no fundamental correspondence, that is to say—to the distinctions between the sciences. Properly speaking, there are no sciences, but only science. The student might as well attempt to understand the anatomy of man without physiology, or the physiology of man without anatomy, as to study physics or chemistry independently. This is one of the reasons why we have, as frequently as possible, inserted cross-references between the courses upon these two subjects, and why one and the same topic has not infrequently been dealt with in both—now from the more distinctively chemical, now from the more distinctively physical point of view. But, indeed, the more the sciences advance, the more they come to depend upon one another; and so the man who would be master of any one science must have some knowledge of all—the more the better.

Now, what has been the tendency in the case of the two sciences under discussion? Do they still stand on a level? Are they sisters? to repeat the common term. The answer most emphatically is that they are not. One has gained supremacy over the other. Nay, more; it has actually been able to include the other as one of its own subdivisions. The reader will not need telling which has become the dominant science. Were he in such need, we might again quote the profound saying of Bacon, who, centuries before the truth of his words was verified, declared that natural philosophy—a term practically equivalent to physics, which is, of course, derived from the Greek word for nature—is the "great mother of the sciences."

The New Science of Physical Chemistry. Modern chemistry must acknowledge its filial relation to modern physics. If not today, then tomorrow, or the day after, all the phenomena of chemistry must be not merely included among the phenomena of physics, but must be explained in physical language and regarded as physical phenomena, differing in kind not one whit from the phenomena which men have long recognised as coming under the heading of physics.

From one point of view, we may say there has been born a new science, *physical chemistry*, and this term does afford convenient means of indicating a certain series of inquiries; but all chemistry is really physical chemistry, and is more clearly seen to be physical chemistry the more nearly it approaches perfection. Thus, this question of the ultimate nature of matter is equally and alike a physical and a chemical question. Here we must attempt to discuss it more especially, of course, from the chemical point of view, asking questions which are especially suggested by chemistry—questions as to so-called chemical energy, as to valency, as to the nature of the forces which determine the combination of elements for the formation of compounds, as to the decomposition of compounds, and, in short, all those interrelations of matter commonly distinguished as chemical.

The Limit of the Older Chemistry. And, in the first place, we must decide how far the older chemistry takes us, and the answer, of course, is that the older chemistry takes us as far as the atom. Nineteenth century chemistry was, indeed, based in the main upon the theory of atoms. On the other hand, students of this and its companion course have already found reason to see that the atom is not an ultimate; and here we must insist upon an extremely important truth which is in very grave danger of being neglected at the present time. The casual reader is extremely apt to be misled, and, unfortunately, the casual writer as well. So soon as the physicists rudely disturbed the equanimity of the chemist by resolving the atom into smaller particles, people arose who said that, for instance, "the whole structure of modern chemistry has been swept away at a blow." That is, indeed, a nice, comprehensive statement. For just a century chemists had been accumulating facts in thousands and tens of thousands which seemed

capable of explanation on the atomic theory, and on that alone. Our notions of molecules, and of molecular constitution, our conceptions as to what constitutes a compound and differentiates it from a mixture, our positive and experimental knowledge—not theoretical knowledge, be it observed—of the laws of valency and of atomic heat, the law of Avogadro, and many more—all these, forsooth, were to be swept away at a blow because the old conception of the atom could no longer stand. But let us consider the matter, since otherwise we are not likely to go far in our search for an answer to the root question of chemistry. The case is plausible enough. An atom is, by the derivation of the word, a thing which cannot be cut. Whatever else may or may not be true of it, at least it is a chemical as distinguished from a physical ultimate.

Upon the theory of atoms there was indeed thus erected the imposing and seemingly stable structure of nineteenth century chemistry.

Complexity of the Atom. But now there comes the physicist, who tells us that an atom is not an ultimate, but is a complex body, consisting, in the simplest instance, which is the atom of hydrogen, of some seven hundred to a thousand smaller particles, which bear some such relation of size to it as a full-stop bears to St. Paul's Cathedral. The hasty observer has, indeed, some ground for thinking that the foundation has been swept away, to the utter ruin of the superstructure; and unquestionably this view would be not merely plausible but also correct *if the essential part of the conception of the atom were its indivisibleness.* Now, it is this part of the conception which is usually regarded as essential. The present writer was taught that this is the essential of the atom: the textbooks regard it as such; the less philosophic chemists, generally, have regarded it as such; and the very meaning of the name goes to confirm this view. Nevertheless, we maintain and propose to prove that, during all this time, the emphasis has been laid upon a part of the conception of the atom which is not essential, which is of no importance whatever for the atomic theory, and which, to boot, is demonstrably false.

John Stuart Mill's Anticipation. The explanation of the whole matter is to be found in a really remarkable paragraph occurring in Mill's "System of Logic," which dates from as long ago as the year 1843, the year before the death of Dalton. In the introduction to his great work, Mill attempts to define logic and estimate its province. He declares that he must "attempt a correct analysis of the intellectual process called reasoning or inference," and then he goes on to say:

"With respect to the first part of this undertaking, I do not attempt to decompose the mental operations in question into their ultimate elements. It is enough if the analysis, as far as it goes, is correct, and if it goes far enough for the practical purposes of logic considered as an art. The separation of a complicated phenomenon into its compound parts is not like a connected and interdependent chain of proofs. If one link of an argument breaks, the whole drops to the ground; but one step towards an analysis holds good, and has an independent value, though we should never be able to make a second. The results of analytical chemistry are not the less valuable though it should be discovered that all which we now call simple substances are really compounds. All other things are, at any rate, compounded of those elements; whether the elements themselves admit of decomposition is an important inquiry, but does not affect the certainty of the science up to that point."

How the Atomic Theory is Affected. Mill's argument is that it does not matter whether the atoms of the elements may be shown themselves to admit of decomposition, since, however important that question may be, the answer to it has no bearing upon the conclusions to which the atomic theory has already led us. The notion that the atom is indivisible does not constitute a link in the chain of argument which we call the atomic theory. Mill admits that, if it did so, the whole theory would drop to the ground.

But observe how remarkable is the applicability of Mill's illustration to our present difficulty. We have gone far to prove, and, beyond a doubt, will shortly go all the way to prove, that "all which we now call simple substances [elements] are really compounds." But this does not matter. Neither chemist nor physicist doubts that, as Mill said, "all other bodies except those so-called elements are at any rate compounded of those elements." This fact remains a fact, as is the nature of facts, and is affected in no degree at all by the modern discovery of the decomposition of the elements.

What, then, must we give up? Certainly we must abandon what may perhaps be called, in order to distinguish it, the "atomic theory of the atom," the theory that the atom is literally atomic, or indivisible. Indeed, it has been suggested that the term "atom" must be transferred to the corpuscles, or electrons, of which atoms are now known to be composed—corpuscles which seem to be, indeed, atomic, or indivisible. But it would be a great mistake to transfer the name in this fashion, even though, on the score of its derivation, it is quite inapplicable to what we now call atoms.

Atoms are Realities. But whether or not we give up the name, certainly there is no chance of our giving up the conception. No one again, indeed, will ever liken atoms to foundation-stones, or declare that they bear upon them the "stamp of the manufactured article." Such phases cannot be permitted in the light of the conclusive evidence which we now possess of the evolution of atoms, the heavier and more complex having been demonstrated in several instances to break down into the lighter and simpler. But, as the present writer has said elsewhere—and the illustration is perhaps significant—"we no

more question the existence of atoms because we are beginning to understand their structure, and the nature of the actual elements of which they are composed, than we question the existence of animal organisms because we know they are all composed of cells ; of cells because we know they are all composed of molecules ; or of molecules because we know they are all composed of atoms."

The Theory is Really Strengthened. But this is not all. So far are these new discoveries from having swept away at a blow the whole structure of modern chemistry that they have actually afforded signal support to this great structure, which stands far more securely with their assistance than it previously did. Let us take an instance. The reader is familiar with the periodic law—to which we have already been compelled to pay an amount of attention which would have seemed ridiculous twenty years ago. The law asserts, the reader will remember, that, if the elements be arranged in the order of their atomic weight, certain groups of characters are found regularly to recur, so that the characters of an element are a periodic function of its atomic weight. This law has vindicated itself by leading its propounder, Mendeléef, to predict the discovery of elements which have now, indeed, been discovered, and which actually have the characters he assigned to them, just as the law of gravitation vindicated itself by leading to the discovery of Neptune. We may also remind the reader that the group of rare gases found in the air has astonishingly fitted into the periodic table. But upon what is the periodic law based ?

Value of the New Conception. Most evidently the periodic law is based upon the conception of atomic weight, and this, of course, upon the atomic theory ; and this, forsooth, far more certain today than ever it was, is declared to have been "swept away at a blow." But we have declared that the law will furnish an illustration of the view that the new conception of the atom makes still more secure the structure of modern chemistry ; and the fact to note is that it is the new theory of matter, the theory which implies the disintegration of the atom, that alone affords an explanation of the manner in which the elements are related to one another, the manner in which the atoms of various elements display a tendency to unite with one or more atoms of other elements, and the manner in which the properties of elements seem to recur as one passes onwards from those of less to those of greater atomic weight. There is no essential part of the atomic theory which has done anything but gain in consequence of recent work. The notion that in the atom we have the ultimate result of analysis has never satisfied philosophers—as our quotation from Mill suggests—and although on a superficial view this notion may appear to be the essential part of the atomic theory, it is really not so at all.

The "Life" of Atoms. We have, then, to conceive of matter, in all its common forms at any rate, as being reducible—not ultimately, but still in a certain stage of analysis—to bodies which we still call atoms. These atoms themselves may be immeasurably complex, but they are no more without individual existence of their own, on this account, than St. Paul's Cathedral is without an individual existence because it is made of stones, or than the body of an animal is without an individual existence because it is made of cells. For the *ordinary* purposes of chemistry these atoms may indeed be regarded as ultimates, and they are a surer, because a truer, foundation for chemical science than they were when we had no better conception of them than Dalton's or Clerk-Maxwell's. But since they are not ultimates, they are subject to the common fate of everything else that is not ultimate—they are subject to birth, development, disintegration, and decay. The chemist studies them mainly in what we may call their adult stage. Their lives are extremely long in the great majority of cases, and thus there are immense periods during which, for the purposes of the chemist at any rate, they may be regarded as permanent. The law of the conservation, or indestructibility, of matter—that is to say, of atoms—cannot stand vigorous criticism, dictated by recent knowledge. But the periods of stability are so prolonged in the case of all but a very few atoms that the chemist is able to proceed as if the law of the conservation of matter were really true

The Change in 12,000,000 Years. In the course of ordinary chemical decompositions and the like, atoms do not disappear ; chemical equations such as those of which we have seen many examples are not fictions, but correspond to truths ; and when it is demanded of a chemical equation that the same number of atoms and the same number of each kind must always be represented on both sides of the equation, or else it is no equation and falsely represents the chemical facts, we are making no unreasonable or imaginary demand, but one which is imposed upon us by the facts. In the course of ordinary chemical actions atoms do not disappear ; nor, on the other hand, do they come into being. The physicists tell us, and provide abundant proof of the assertion, that these atoms, of which we write as if they were so many permanent bricks, are really undergoing slow change—that in 1200 years atoms of one kind will have changed into atoms of another, or that in 12,000,000 years atoms of a third kind will have changed into atoms of a fourth. Meanwhile, we, whose observations are confined to minutes or days or a few years, are at liberty to assume, for practical purposes, that the stable period of all familiar atoms except the very heavy ones is permanent.

Man and the Atom. And here we are in a position to make an important distinction. Just as in the case of a member of a society, we may raise two inquiries concerning an atom. A man may be considered from two points of view. We may ask concerning his internal processes, as to what he thinks in his heart of hearts, as to how his mind develops and

changes and reaches, perhaps, a changeless period, as most minds do in later life; and, on the other hand, we may consider the man in his relation to other men. On the one hand, we consider him simply as an individual; on the other as a member of a greater whole; but while we observe this distinction we must remember the principles laid down in the beginning of this chapter, and realise that at bottom the distinction is an arbitrary one. A man's life is not made up of two independent sets of processes—one individual and the other social. On the contrary, these are incessantly reacting upon one another.

Now let us see how this analogy helps us. In the case of atoms, we used to think that there was only one set of processes to consider—the social processes, so to speak. Chemistry accepted atoms as changeless and permanent, and its business was, and, indeed, still is, to ascertain the way in which atoms behave in relation to one another. If we could ascertain this in its entirety, we should have, it seemed, a perfect chemistry. There did not seem to be the slightest reason to suppose that there were any other processes than these. But now we know better. Physicists have taught us, not, as incompetent commentators aver, that atoms are a "baseless fiction," but that atoms have their individual processes, as well as their social processes. It is with the latter that chemistry, as it used to be conceived at any rate, is concerned. It is the former, the existence of which was, until lately, unsuspected, that is now exciting the interest of all students. We may use two convenient terms to express the difference.

Social and Individual Processes. The material processes which we have to study may be described as belonging to two groups—the inter-atomic and the intra-atomic (from Latin *inter*, between, and *intra*, within). But this analogy between the human and atomic organism—for which the present writer must take the responsibility—is even more complete and, we think, valuable than has yet been indicated. For we have said that it is impossible in point of fact to consider the social and individual lives of men as if they were independent. On the contrary, the truly wise student of society knows that the key to social phenomena is human nature. What does this mean? Plainly, that the social processes can never be really understood so long as we assume either that they are all the processes to consider or that the individual processes have no relation to them. In order to understand the relations of human beings it is absolutely necessary to study the characters of individual men, which determine all these processes, and these characters can be understood only if we study the internal individual processes of men. *As a man thinks, so is he.*

The Atom Vindicated. And it is so with the atom. The facts are directly opposed to the statements of those who say that the discovery of the intra-atomic processes has swept away the structure of the older chemistry, which is concerned with the inter-atomic processes.

The discovery of the intra-atomic forces and processes is already illuminating, and will more and more continue to illuminate and amplify our knowledge of the inter-atomic processes. Furthermore, our knowledge of the intra-atomic processes is leading us to our first real comprehension of the already known characters of atoms and their behaviour. And the modern chemist is just coming to realise—as we shall see, ere long—that the internal processes of the atom determine its character, and thus its relations to other atoms—that is to say, its inter-atomic processes, its chemical behaviour. Was anything more ludicrous ever said than that these new discoveries have caused the atomic theory to be "scrapped on the dustheap of antiquated hypotheses"?

Analysis of the Atom. We have deliberately discussed this subject at great length, since it is absolutely necessary to do what may be possible in order to counteract a misconception which is extremely widespread, which is still, as many quotations might show, gaining ground among the uninitiated, and which, unfortunately, strikes at the very root of any real understanding of chemistry. Atoms unquestionably exist, and constitute the ultimates of the elements as we know them.

Now, it may not unreasonably be argued, one would think, that the business of the chemist stops at this point; that directly we begin to analyse the atom, to concern ourselves with the intra-atomic processes, we are wandering from our subject, which is, properly speaking, the social aspect of atomic life; we are committing the fault of the sociologist who begins to study individual psychology. But these barriers and distinctions and delimitations are relics of an outworn order of thought, or, to change the metaphor, they are like temporary scaffolding arrangements which can be removed as the building approaches completion. If it be true that the key to sociology is to be found in human nature, the sociologist is right in studying individual psychology.

Physico—Chemical Study. If it be true that the key to chemical processes is to be found in the internal individual processes of atoms, the chemist is right in considering them. They are the key to everything that interests him; and even if his means of study have to be modified, even if he can dispense with nearly all his test-tubes, even if he require to leave his own laboratory and enter the laboratory of the physicist, and be told that he has forsaken his first love, he must "see this thing through." He cannot be arrested at the edge of the atom. On these grounds, and on those other grounds which we began by stating, we offer no apology for proceeding to study this subject in this course, instead of the course on PHYSICS. In any case we have failed in our task if the interdependence of the two courses has not been made manifest.

C. W. SALEEBY

Fall of Constantinople. Discovery of the New World and Rise of Spain. Decline of Italian Republics. Rise of Austria by Marriage.

THE PASSING OF THE MIDDLE AGES

ENORMOUS as have been the changes in the aspect of the world and in human life which have been wrought by the last fifty years, it may probably be asserted with truth that at least equal changes were wrought by the events which occurred in the last half of the fourteen-hundreds.

The first of these was the fall of Constantinople (May 29th, 1453). While emperors and kings were still playing with the question of possible crusades, for which popes were pleading in deadly earnest, the believers in Islam, reversing the crusading process, crossed the Bosphorus and took the great city which for more than a thousand years had preserved in strange union the two memories of Cæsar and of Christ. Western Christendom was horrified at the news, but did little to stay the onrushing Ottoman tide which for more than 200 years—till the unsuccessful siege of Vienna in 1683—was always more or less of a terror to Europe. But cruel as was the loss to the East, the West was in some sort a gainer, by the dispersion of eminent scholars who reinforced the ranks of the Humanists—the lovers of the illustrious classical literature of bygone ages and the opponents of the schoolmen—both by their oral teaching and by the priceless manuscripts which they preserved from the sack of Constantinople.

As was finely said by a modern scholar: "At this time Greece arose from the dead with the New Testament in her hand." This new learning, powerfully aided by the art of printing, which was invented somewhere about 1450, set fermenting in the minds of such men as Erasmus and Luther thoughts which were destined to work marvellous changes in the mental atmosphere of Europe. Geographically, the voyages of discovery which signalised the closing years of our present period were the most important that were ever made since the first Phœnician mariners pushed through the Pillars of Hercules into the vast and shoreless Atlantic.

Throughout the fourteen-hundreds the work of maritime discovery along the east coast of Africa had been entirely undertaken by the Portuguese, who were cheered on their adventurous career by the patronage of their noble prince, Henry the Navigator, a man who had English blood in his veins, being the grandson, on his mother's side, of John of Gaunt, Duke of Lancaster. From his eyrie on Cape St. Vincent he watched the departure, in 1419, of two frail vessels which sailed a little beyond the Peak of Teneriffe. Later voyages were much more successful, and before his death, in 1460, the Portuguese discoverers had crept down to the neighbourhood of Sierra Leone, twenty degrees nearer to the Equator than that ominous Cape Nam (Cape No) which, when Prince Henry began his enterprise, had been the southern limit of European navigation.

After the prince's death his great work went steadily forward. Guinea and the Gold Coast, the mouth of the mighty River Congo, and Angola were discovered, and in 1486 Bartholomew Diaz, a knight of the royal household, with the double hope of discovering a passage to India and meeting with the mythical Prester John, steered due south for many days and discovered the promontory which he called the Cape of Storms, but which the Portuguese king on his return insisted on renaming the Cape of Good Hope. But the long eastward bend of the coast of South Africa seems to have hidden from him and his sailors the real meaning of their discovery. It was not till eleven years later, in 1497, that the illustrious Vasco da Gama succeeded in fairly rounding the southern end of the great continent, and, steering across the Indian Ocean, reached Hindustan, and beheld the Zamorin of Calicut in his palace.

It is a strange thought that the vain hope of doing in another way that which was thus accomplished with comparative ease by Vasco da Gama had driven Christopher Columbus, five years previously, in 1492, on his desperate voyage westward across the Atlantic. On the well-known circumstances of those memorable months of suspense, which ended on October 11, when Columbus, standing

on the poop of his vessel, saw the moving lights of Guanahani, there is no need to dwell. Only we ought to emphasise to ourselves the change which the discovery of this Western world, expanding every year, as it evidently seemed to expand, by the reports of the successors of Columbus, must have wrought in the mind of the ordinary, commonplace, mediæval European. It is perhaps not too much to say that it was as great as that which would be wrought in us by the discovery of a means of communication with the inhabitants of Mars or Venus.

Spain Steps into the Front Rank. It was hard that, when a Portuguese prince had been the prime mover in this crusade of discovery, the glory and the gain of it accrued chiefly to the Spanish sovereigns. As the well-known motto on the tomb of Columbus, dictated by Ferdinand of Arragon himself, ran:

A Castilla y a Leon
Nuevo mundo dio
Colon.
(To Leon's and to
Castile's throne
Columbus brought a
world unknown.)

Besides the discovery of America and the riches resulting therefrom, many other causes concurred in the fourteen-hundreds to push Spain, hitherto somewhat solitary and self-absorbed, into the front rank, the fighting-line of the nations of Europe.

Disunited Spain's Conflict with the Moors. In the seven centuries that had elapsed since the Moorish conquest, she and the sister state of Portugal had been slowly winning back their country from the Moors. At first the process was a slow one, but in the twelve-hundreds, after the great Christian victory of Navas de Tolosa, in 1212, it went forward with giant strides, and by the middle of that century the only region of Spain left to the Moslems was the fertile but comparatively small province of Granada. There, however, a compact kingdom was founded, which endured for more than 250 years (1238-1492). One reason for its continuance—probably the chief reason for all the long pauses in the Christian advance—was the number of petty kingdoms into which the peninsula was divided. Leon, Castile, Navarre, Barcelona, Arragon, Portugal—all had for long their separate existence, and were frequently at war with one another.

LORENZO DE MEDICI
From the painting by Vasari at the Uffizi Gallery, Florence

The Conquest of Granada. Now, however, at last, by the marriage of Ferdinand of Arragon with Isabella of Castile in 1469, almost the whole of Spain was united in one powerful monarchy. The exception was Navarre, which was not appropriated by Ferdinand till 1512. The actual union of Arragon and Castile did not take place till 1479, on the death of Isabella's brother, Enrique IV. One of the earliest enterprises of the royal pair after they had come into full possession of their sovereignty was the annexation of Granada. For ten years the war went on, the patient strategy of Ferdinand being greatly aided by domestic quarrels in the Moorish palace, son rebelling against father, and uncle fighting against nephew. At length, on January 4th, 1492—three months before Columbus set sail from Seville—the last blow was struck. Granada itself, hopelessly blockaded, surrendered to the Christians, and its weeping king, Abu Abdallah, looking his last on its stately pinnacles, rode forth into exile.

Intolerant Christianity. The subjugation of the last Mohammedan state in Spain was perhaps regarded by Christendom as some slight compensation for the loss of Constantinople. Unhappily, the Christian sovereigns showed themselves less tolerant towards their conquered subjects of another faith than the Turkish sultan. Ferdinand's promises of toleration for the Mussulman Moors were soon evaded; forcible conversions were attempted; the Inquisition put forth its baneful energies—everything was prepared for that disastrous revolt of the Moriscos, disastrously quelled, which inflicted so deep a wound on Spain in the following century.

A Tragic Lack of Heirs. The "kings" of Arragon and Castile, so fortunate in all else, suffered the disappointment of seeing their male issue expire in their own lifetime. It was evident that their magnificent inheritance must fall to the lot of the descendants of one of their daughters; and that daughter eventually

COLUMBUS PLEADING WITH ISABELLA, QUEEN OF SPAIN, FOR SUPPORT IN HIS EPOCH-MAKING ENTERPRISE

CHRISTOPHER COLUMBUS MOCKED BY THE LEARNED TEACHERS OF THE OLD WORLD

THE BLOW FROM WITHIN WHICH SHATTERED THE WORLD-WIDE DOMINION OF SPAIN

THE HON. JOHN COLLIER'S PICTURE OF THE SPANISH INQUISITION, WHICH DRAINED THE NATION'S LIFE OF ITS BEST FORCES

proved to be Princess Joanna, wife of Philip of Hapsburg, whose eldest son, Charles, the future Charles V., was born in the last year of the century, the fateful year 1500.

French Claims on Sicily. Meanwhile, during the whole of the previous period, there had been a growing community of interest between the two peninsulas, the Spanish and the Italian, and a growing tendency in Italian affairs to embitter the relations between Spain and France. Two successive queens of Naples, descendants of Charles of Anjou, Joanna I. and II., both of them women of tainted reputation, had embroiled the politics of Italy by adopting as their heirs both French and Spanish princes. The French claimants, three successive Louis of Anjou, had never succeeded in making good their title for any lengthened period, and the last of the line, "le bon roi Réné," troubadour and master of pageants, but more interesting to Englishmen as father of Margaret of Anjou, of fatal memory in our civil wars, was himself as shadowy a king of Naples as his forefathers were before him.

Spanish Claims on Sicily. But in 1442 the great prize fell to another adopted son of the latest Joanna, to Alphonso, king of Arragon, and also king of Sicily. Thus at last was the death of Conradin fully avenged, and the descendant of Frederic II., king of both the Sicilies, possessed the full inheritance of his Norman forefathers. On his death, while his Spanish dominions and Sicily went to his brothers, Naples, which he had won with his sword and with his bow, became subject to his illegitimate son Ferdinand; and thus till near the end of the fourteen-hundreds we have the Sicilies again disparted, Naples itself ruled by this Ferdinand, and Sicily by his first cousin, Ferdinand of Spain, the husband of Isabella. And over all hovered the spectral, shadowy claims of the titulars of Anjou, which had bred wars in the past and were likely to be the cause of wars to come.

Notwithstanding these dynastic conflicts, the solid strength of Il Regno, as the kingdom of Naples was called, was always looked upon with something of envy and admiration by the northern states of Italy. There almost every city was at war with its nearest neighbour, the trade of the condottieri flourished, and, as before stated, the turbulent freedom of the republics which had leagued against Barbarossa was being crushed under the heel of petty local despots. An Italian patriot surveying the condition of his country in 1453 might well think that the liberation from the yoke of the empire, which had been won by generations of Guelfs, had been after all but a doubtful blessing.

The Rise of the Medicean House. One of the last of the republics to fall into slavery—and even after her fall she struggled up once and again into liberty—was Florence. In 1464 died old Cosmo de Medici, who, by the combined influence of wealth, eloquence, liberality, and some real patriotism, aided by the blunders of his opponents, had made himself virtual master of his native city. It was certainly a wonderful story, that of the Medicean House. They had no claims to feudal nobility; the party which they led was by profession the Liberal party; Cosmo himself with his vast wealth might be looked upon as the Gladstone-Rothschild of Florence; yet he succeeded in leaving to his offspring a power which, in the hands of his grandson, the "Magnificent" Lorenzo, was little less than regal; his collateral descendants for two centuries were grand dukes of Tuscany, and their blood, through the intermarriage of Catharine and Marie de Medici with the kings of France, now flows in half the royal families of Europe.

Venice Becomes an Oligarchy. Lorenzo de Medici died in 1492, the same year which, for other reasons, we have already seen to be indeed *annus mirabilis.* The other great Italian commonwealth, Venice, preserved indeed through all her more than a thousand years of life her republican freedom, but changed her popular character in 1300 by the act known as "the Closing of the Grand Council," which limited the right of election to the great offices of state to certain aristocratic families, and she thus became that jealous and suspicious oligarchy whose methods have been so faithfully and dramatically described by many a tragedian and writer of romance.

Venice Mistress of the Seas. In the periods which now lie behind us she had many a bitter struggle with her rival Genoa, in one of which, the war of Chioggia (1378-1381), she all but lost her national life; and the domineering Viscontis of Milan had, especially towards the close of the thirteen-hundreds, rolled up dangerously near to her borders. Since then, however, the tide of conquest had turned; she had become a great land-power as well as a sea-power, and in the period before us it may be roughly computed that she was mistress of two-thirds of Lombardy, the remaining, the western third, being under the dominion of the dukes of Milan.

The Sforzas Marry Their Way in Milan. Those dukes were no longer Viscontis but Sforzas, the renowned condottieri general, son of a Romagnole peasant, Francesco Sforza, having succeeded with infinite trouble in winning the hand of Bianca, daughter of the last Visconti (Filippo Maria), who died in 1447, leaving no legitimate progeny. Thus were the Sforzas established on the throne of Milan, where they reproduced most of the unamiable characteristics of their Visconti ancestry. In 1492, the year to which so much of our narrative converges, the young prince, Gian Galeazzo Sforza, was nominally reigning in Milan, the real ruler being his uncle Ludovico il Moro—so named from his swarthy complexion—who was generally believed to be plotting his nephew's murder.

Here, however, as well as in Naples, there was also a French claimant, in the person of the Duke of Orleans, who was descended from a legitimate Visconti princess, while the Sforzas could claim only through Filippo Maria's bastard daughter.

The Papal Power Established Round Rome. Of the condition of the papacy during the half-century now under review it is not easy to speak. Unfortunately Nicolas V. had few successors like-minded with himself. The pontificates of Sixtus IV. (Francesco della Rovere) and Alexander VI. (Rodrigo Borgia) were an open scandal to Christendom ; and that of Alexander, which began in 1492, was undoubtedly one of the events which prepared the way for the Reformation. It is perhaps a matter of praise rather than blame that all the popes of this period were eager for the strengthening of the temporal dominion of the Church in Central Italy. After the troubles of the last two hundred years, the turbulence of Rome and the absurdities of the Avignonese "captivity," it was certainly a more sensible policy to try to build up a secure and independent papal state on the basis of the old "donations" than to repeat the obsolete pretensions of a Hildebrand or a Boniface to the deposition of emperors and the government of the world.

The Wars of the Roses Break Baronial Power. Turning now to the northern nations, we find that the later fourteen-hundreds were a dreary time for England. In 1445, only two years after England's expulsion from France, began those terrible Wars of the Roses in which it is difficult not to see the righteous judgment of Heaven on the nation which had so wantonly devastated the fair fields of France.

One change, possibly beneficial, was the result of these sixteen years (1455-1471) of more or less continuous fighting. By them, and by the increasing use of artillery, which made the mediæval castle no longer impregnable, the power of the old feudal baronage was to a great extent broken, and king and people were left practically alone to make what they could of their country's fortunes. The century closed with Henry Tudor, the silent, statesmanlike, unamiable king, hoarding the treasures which were soon to be scattered by his lusty son, Henry VIII.

Louis the Eleventh of France. In France a somewhat similar process was going on under the rule of Louis XI. (1461-1483). The characters of these two kings, Henry and Louis, present some points of resemblance, though it would not be fair to put that eminently respectable and devout paterfamilias Henry Tudor on a level with the unscrupulous Louis of Valois, who hesitated at no crime to attain his ends, and who spent his lonely old age surrounded by his hireling Scottish archers, in abject fear of death, "rising up at the voice of a bird," and oscillating between blasphemous irreverence and abject superstition. Yet Louis XI. had also some clear perception of the duty which he owed to the country over which he ruled. He was a most industrious king ; he encouraged commerce and learning, and even in his successful endeavours to free himself from the strait-waistcoat of the feudal nobility, by which at his accession he found himself constrained, he had probably some consciousness that he was working for his people as well as for himself. The first revolt of the nobles against him called itself "The League of the Public Weal." Reviewing his reign at its close, he might fairly have said, "At least I did more than they for the public weal to which they professed their devotion."

ABU ABDALLAH THE MOOR SURRENDERS GRANADA TO FERDINAND AND ISABELLA OF SPAIN

THE PLUCKING OF THE ROSES IN THE GARDEN OF THE TEMPLE

THE DEFEAT AND DEATH OF RICHARD III. ON BOSWORTH FIELD IN THE YEAR 1485

Swiss Pikemen Shatter Burgundian Ambition. Chief of all the antagonists of Louis XI. was, of course, the head of the great House of Burgundy, Charles the Bold, who, with his wide domains for which he owed vassal-homage partly to France and partly to the empire, aspired to make himself independent of both realms, and would probably, had he lived and conquered, have founded a middle state, a kingdom of the Rhine, or something of the sort, which might have proved itself a blessing to Europe as a "buffer state" between France and Germany. This, however, was not to be. After years of open or secret conflict with his cousin Louis XI., a war of the Lion against the Fox, in which the Fox once or twice very nearly perished, he became involved in hostilities with his southern neighbours, the peasants of the Switzers' confederation. To the surprise of Europe, the Swiss peasants overcame the mighty feudal lord; the stoutly held pike vanquished the battle array of chivalry. In three battles, Granson in 1476, Morat in 1476, and Nancy in 1477, Charles was completely beaten, and after the last a page found his dead body lying covered with wounds in a frozen swamp—the battle was fought on the fourth of January—and the Switzers bore it into Nancy for burial.

Burgundy Marries into the Empire. In that frozen swamp lay dead the schemes of the aspiring House of Burgundy; and yet in a certain sense they rose again when Charles's orphaned daughter Mary gave her hand to the heir of the House of Austria. This heir was Maximilian. The Emperor Frederick III., who slumbered on the imperial throne for fifty-three years (1440-1493), did, at any rate, one sensible thing when he married, in 1452, the clever and beautiful Princess Eleonora of Portugal. The offspring of this union, Maximilian, born in 1459, was almost the last of the knights errant of Europe, a versatile and accomplished but somewhat unstable prince, a mighty hunter but an erratic statesman, who was elected king of the Romans in 1486, and who, on the death f his father, obtained the imperial crown.

Spain also Marries into the Empire. All this, however, was still in the future, when, soon after the death of Charles the Bold, his daughter, beset with enemies on every side, gladly gave her hand to the goodly young knight Maximilian, saying: "Welcome, thou noble German blood! How has my heart longed for thee!" It was a happy union, too soon closed by death—the young duchess died in 1482—but it changed the fate of Europe, for the issue of this marriage were two children, a son and a daughter, and the son, Philip the Handsome, is the prince who, as we have already seen, married Joanna, daughter of Ferdinand and Isabella, and thus transmitted to his son Charles the heirship to the crowns of Spain and the New World.

LOUIS XI. ENTERING PARIS AFTER THE BATTLE OF MONTLHÉRY IN 1465

The Growth of Hapsburg Rule. Let us just consider to what a height the House of Hapsburg, founded by the little Swabian knight only two centuries before, had now reached. They owned the Austrian provinces, Tyrol, Styria, Carinthia, Archducal Austria, etc., by inheritance; they had acquired, by Maximilian's marriage with Mary of Burgandy, the wealthy and populous Low Countries, Holland and Belgium, together with Franche Comté—this.

which was called the County of Burgundy, escaped for the time absorption by France. The duchy of Burgundy was successfully assimilated by Louis XI. on the death of Charles the Bold. Spain, too, and the Indies became theirs when Ferdinand and Isabella had gone; and the child born at Ghent in 1500 had a better chance of being elected to the crown of the Holy Roman Empire than any of his contemporaries.

Fortune-hunting in Empires. Later on—but this is beyond our present horizon—Bohemia and Hungary fell to a son of the same House, Ferdinand of Austria, by his marriage with Anne, the last of the House of Luxemburg.

Well might other European Houses have looked with envy and amazement at the immense possession earned by this simple process of marriage, a sort of fortune-hunting in empires.

LOUIS XI. OF FRANCE ON A VISIT TO ONE OF HIS PEASANTS
(By permission from the painting by Mr. J. Seymour Lucas, R.A.

The Contest for Empire. It was probably clear to anyone who, with statesmanlike vision, surveyed the political horizon in the year 1500 that there was an inevitable struggle impending between two great states. On the one side was this wide-stretching Hapsburg domain, clutching at France on her southern, eastern, and north-eastern borders, ruling a large part of eastern Europe, and possessing, for whatever it might be worth, the magic title of Holy Roman Empire, possessing also territories of unknown expanse beyond the Atlantic—truly a boa-constrictor of an empire. On the other side was France, far smaller, but compact, rich in natural gifts and strong in the national spirit, which had been begotten by the hundred years' war with England.

The Contest for Truth. Such a contest, in truth, was the dominating factor in European politics for three centuries, strangely complicated and interfered with by another conflict which was to be born of thoughts already tentatively expressed by the middle-aged Erasmus, but which had not yet begun to germinate in the brain of the "poor scholar," Luther.

Italy the Prize of War. Italy was to be the prize for which the two great powers were first to strive, and the lists were, in fact, opened in 1494 by the Neapolitan expedition of Charles VIII., son of Louis IX. But the story of that expedition connects itself most naturally with the Italian wars of the following century. It seems better, in the words of Hallam, "here, while Italy is still untouched, and before as yet the first lances of France gleam along the defiles of the Alps, to close the history of the Middle Ages."

THOMAS HODGKIN

Thrust Lines. Straight Arch. External Loads. Curve of Thrust. Minimum Depth of Arch Ring. Concentrated Loads. Suspended Chains.

THE STABILITY OF ARCHES

The Thrust of an Arch. The thrust of an arch is the first and most important point for consideration. In **16** is shown the half elevation of an arch, where AB is the half span and BC the rise, DC the depth of arch at the crown, and EA the depth of arch at the springing or abutment. In small arches the spandrel EFGD is generally filled up solid, either by brickwork or masonry; or, in the case of a bridge, by the material of which the roadway is formed, so that while the arch itself is included within the outline AEDC, the load carried by the arch is included in the outline AEFGDC, omitting for the present the consideration of any external load. It is usual to consider the stability of 1 ft. run, the same as with walls; in this case it will be the same as if the elevation shown were 1 ft. thick. The centre of gravity of this figure must be determined by marking the outline upon drawing paper, cutting it out, suspending it consecutively from two points, and marking vertical lines to intersect, giving the point *c. g.* (centre of gravity). Its area must also be determined by planimeter or otherwise, as a measure of its weight. Then a vertical line must be dropped from the centre of gravity and a horizontal line drawn from the centre of the depth of the arch to meet this vertical, to give the intersection from which the weight of half the arch complete must be set off to scale downwards, and from which an inclined line must be drawn through the centre of the skewback. Then the parallelogram of forces is completed by drawing from the bottom of the vertical line a horizontal line to meet the line of thrust through the skewback, and another inclined line upwards, parallel to the first inclined line. Then the length of the lines of the parallelogram marked H and T give respectively the thrusts to balance the load W. The thrusts being obtained, the required depth of arch ring may be calculated according to the strength of the material, and, if necessary, the increased thrust at the skewback may be met by increasing the depth of the arch towards the abutments. In brick arches this is sometimes done by increasing the number of arch rings towards the ends, as in **17**, and in stone arches by increasing the depth of the voussoirs as in **18**.

Straight Arch. A straight arch, such as the gauged arch over a window, is considered by some not to be an arch at all; but if the conditions be investigated, it will be found that it virtually contains an arch ring half the depth of the straight arch, and with a rise of the same amount, as shown by the dotted lines in **19**. This will also show that the angle of the skewback should be such as to lie in a radial line from the centre from which this virtual arch is struck, so as to be perpendicular to the thrust.

Forces Acting on a Voussoir. The forces acting upon a voussoir or arch stone are shown in **20**. The thrust T, from the next higher voussoir, is combined with the weight of and upon the present voussoir to give a new thrust to carry forward to the next lower voussoir. The angle θ must always be less than the limiting angle of resistance, or sliding will occur, and the thrust line must be within the middle third, in order that the effect may be one of pure compression.

External Load on a Bridge. The external load on a bridge due to the traffic may be taken as 2 cwt. to 5 cwt. per foot super., according to circumstances, and added to the diagram, as if it formed part of the dead load of the structure, as shown by the upper portion in **21**. The main thrusts will then be found as before, including this load, and it is usual to show the curve of thrust throughout the whole of the arch. This is done by dividing up the arch into assumed voussoirs and producing vertical lines up to the top; then, locating the centre of gravity of each portion, and dropping vertical lines to represent force lines due to the weights, these weights will be set down in order on the reciprocal diagram **22**, the figures corresponding as in the usual method of drawing the load line on reciprocal diagrams. The horizontal distance [1—0] will then, upon the same scale, be made equal to the horizontal thrust at the crown and vectors, drawn from point 0 to the divisions on the load line, and parallel to these the curve of thrust will be drawn piecemeal across the spaces in **21**, as in the case of an ordinary funicular polygon. For stability, this curve of thrust should preferably keep within the middle third, but if at any point it comes nearer to the intrados or extrados of the arch ring, the pressure on the joint will be greater, but not necessarily too great for safety.

Curve of Thrust. It should be understood that the curve of thrust does not indicate that the pressure is concentrated along that line alone; the line merely shows where the centre of pressure cuts each joint, the resistance being spread over the whole surface of the joint, exactly in the same way as the resistance at the base of a retaining wall is proportioned over the surface of the base, according to the position of the resultant.

Minimum Depth of Arch Ring. It is a curious fact that there is a minimum depth of arch ring, according to the span and rise of the arch, independent altogether of the load upon it.

This arises from the necessity of keeping the curve of thrust sufficiently within the arch ring. A covering arch, 10 ft. span, formed of one ring of brickwork 4½ in. thick, set in cement, was built over a tank and had to carry its own weight only. Before the centering was removed, the arch bulged at the sides, about halfway between the springing and the centre, and when the centering was removed, the arch collapsed altogether. The reason will be seen by observing the position of the curve of thrust as shown in **23** which is constructed from the reciprocal diagram **24**.

The lettering of the illustration shows the order of construction. AB in **23** is the half elevation of the arch, which is divided up not into the actual bricks, but into convenient portions for the method of working. Draw a vertical line through the centre of gravity of each portion, representing the direction in which its weight acts. Number the spaces between these force lines and draw the line of loads CD [**24**]. Select any pole E, and draw vectors to CD. From any point F on line 1—2 of **23** and across space 2 draw a line parallel with the vector from 2 in **24**. Continue across all the other spaces with lines parallel to the vectors, finishing at G. Now draw lines from F and G parallel with the vectors 1 and 14, to meet at H. From J draw a horizontal line through the centre of the arch to meet a vertical line from H at point K; join KL at the centre of the skewback, and produce to give the resultant. Now in **234** draw DM parallel to JK—that is, horizontal—and CM parallel to KL. Join all points on CD with M 15, then these lines will represent the thrust throughout the arch. The "curve of thrust" N is found as follows: from point L across space 2 draw a line parallel with 15—2, then continue across space 3, parallel to 15—3, and so on, until B is reached. For the arch to be stable without tension on any part this curve should be everywhere within the thickness of the arch ring. If the arch be made to the same curve as the line of thrust, the arch will, of course, be under the best conditions of stability, provided that in finding the line of thrust all the circumstances, such as accidental load, wind, etc., have been taken into account.

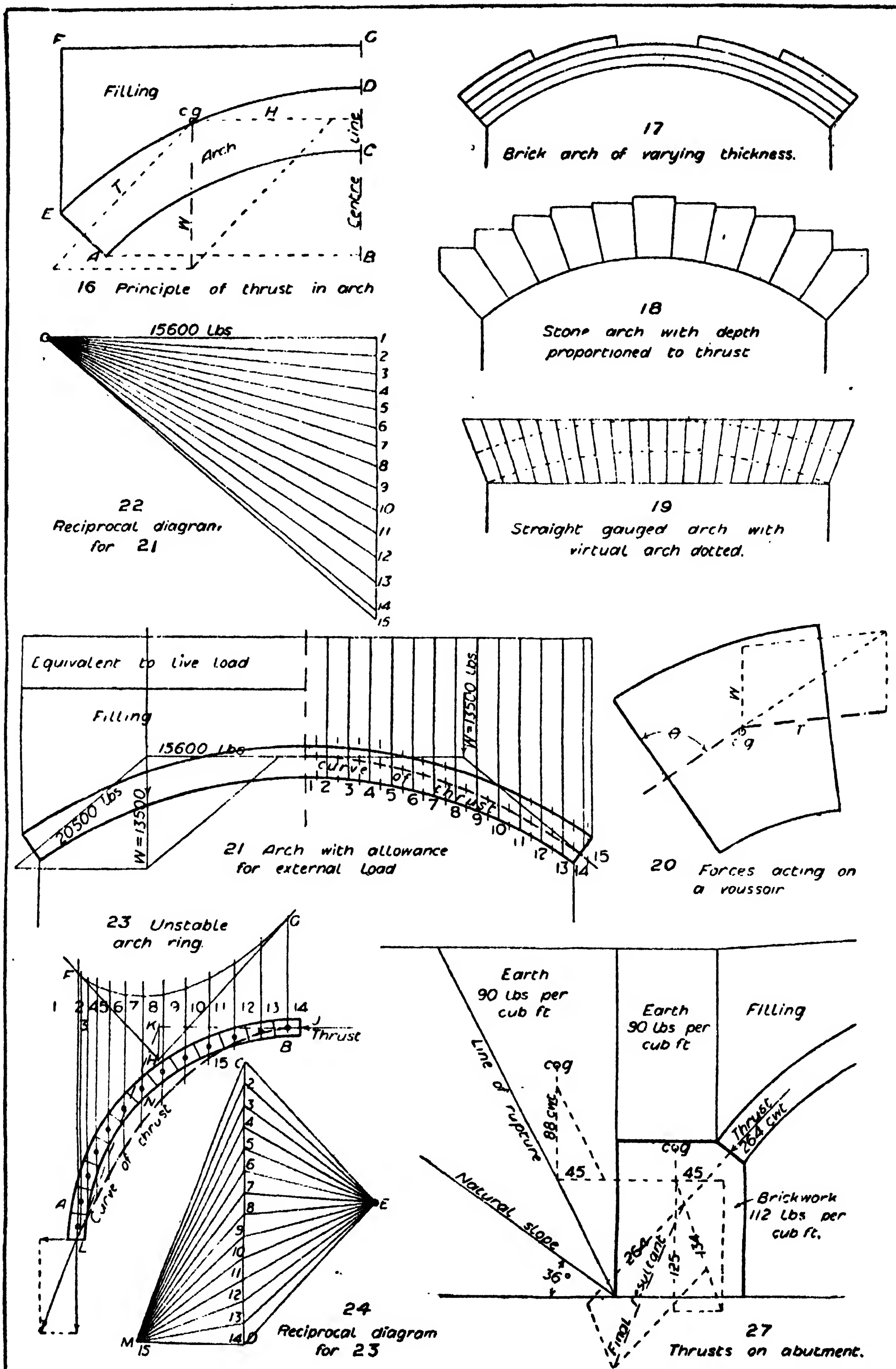
Thrust from Semicircular Arch. It is another fallacy to suppose, as many do, that there is no outward thrust from a semicircular arch. Whatever the horizontal thrust may be at the crown, there is a similar horizontal equivalent on each side acting outwards. An illustration of this occurs in **23,** where the inclined thrust at the skewbacks may be resolved into the two directions, vertical and horizontal, when it will be found that the horizontal component is equal to the horizontal thrust at the crown. It is a law of nature that the line of thrust takes the shortest possible course from the load to the support, so that if an arch ring be assumed to have no weight the thrust from a concentrated load on the centre would pass in straight lines to the skewbacks; and where a distributed load is carried, the horizontal thrust at the crown is depressed by the load it meets as it passes each joint towards the skewback.

Concentrated Loads on Arches. A concentrated load upon an arched bridge, as from the wheels of a steam roller or traction engine, produces a great distortion of the curve of thrust as the load passes over the haunches. Such a case is shown in **25.** The load tends to spread outwards in all directions in passing downwards to the arch ring, but it will be sufficient to consider it as spread over a distance about equal to the depth from the road surface to the arch ring, or even over one or two voussoirs. After dividing up the arch into the actual or assumed voussoirs, and finding the weight above each, the position of the vertical through the mean centre of gravity of all the loads, including the concentrated load, should be found by funicular polygon as shown, and then the mean centre of gravity line for each half. The previous descriptions will enable the method of constructing the reciprocal diagram **26** to be readily understood.

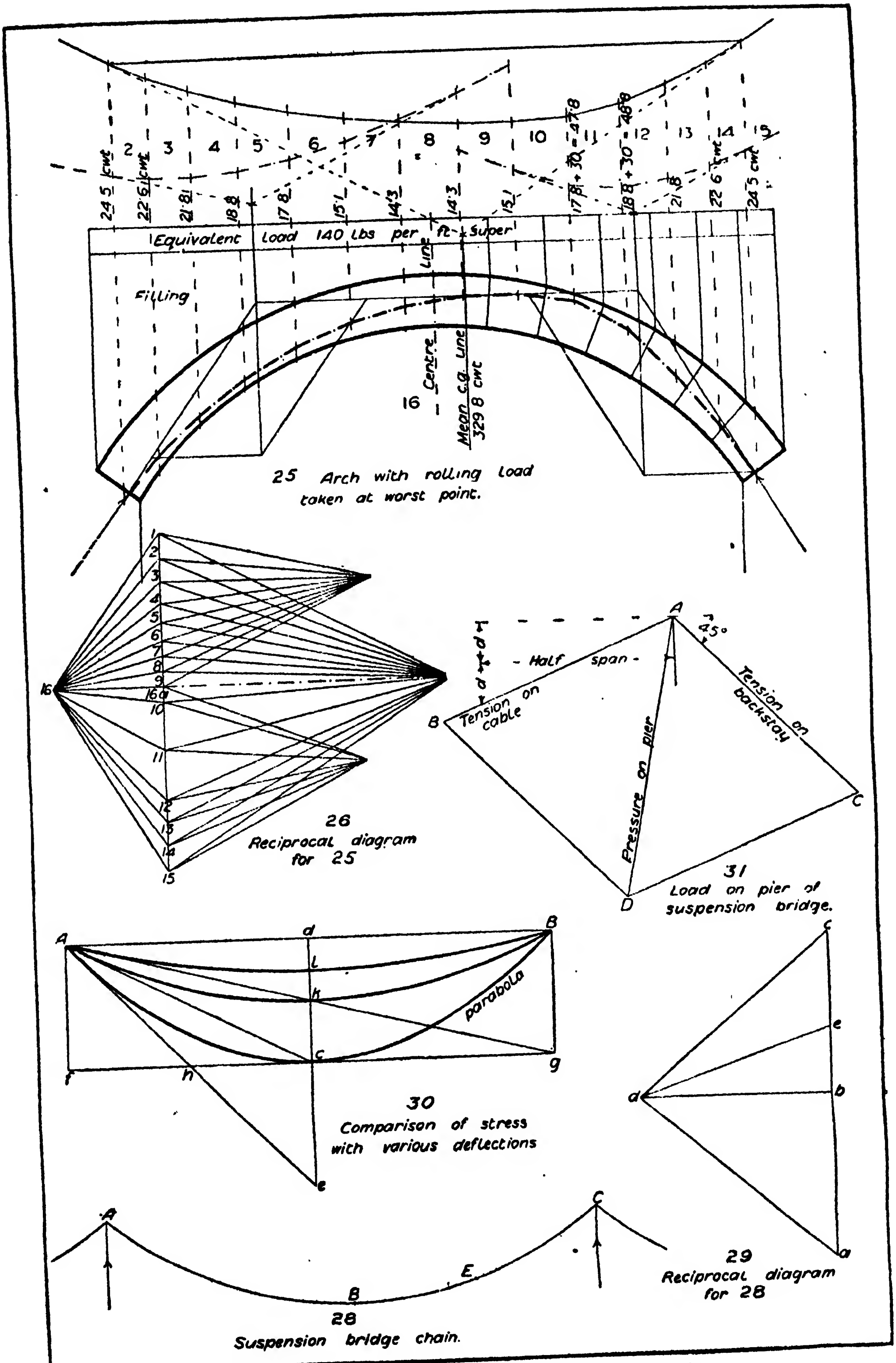
Is a Keystone Necessary? It is a common error to suppose that a keystone is necessary for the stability of an arch; it is purely a matter of taste, and the fact that countless thousands of brick arches exist without a keystone ought to be a sufficient answer to the holders of the idea that it is necessary. In the fronts of buildings the arches are often finished with a keystone or similarly-shaped block of gauged brickwork, but this is for the sake of appearance only.

Stability of Abutments. The abutment of a bridge is generally filled in with earth at the back, and this to some extent resists the thrust of an arch and reduces the necessary thickness. The wing walls of the bridge are continuous with the face of the arch, either in the same plane or at right angles to it, or at some intermediate angle. When curved wing walls are adopted they may commence in the same plane as the face of the arch and terminate at right angles to it. The wing walls give great support to the abutments, but they do not often enter into the calculations. Buttress walls may also be placed at intervals between the wing walls to give support to the abutments, and permit of a reduction in their thickness. A plain abutment without buttresses is shown in **27.** Plain abutments usually stop at or shortly above the skewback, and are then covered by the filling as in this case. To ascertain the stability, the mean centre of gravity of the abutment wall and the earth above it is found, and this weight is combined with the thrust of the earth, then the resultant is combined with the thrust of the arch, and the position of the final resultant with regard to the base of abutment together with the value of its vertical component determines the maximum pressure upon the base.

Stop Abutments. In the case of railway viaducts of several arches, the thrust of one is counteracted by the thrust of the next, so that the abutment or pier between has only the direct weight of the superstructure to carry. If, however, by fire or other accident one arch should fail, all the rest would fall by reason of the unsupported thrust. To prevent this it is



16-24. DIAGRAMS ILLUSTRATING THE STABILITY OF ARCHES



25-31. STRESSES IN ARCH AND SUSPENSION CHAINS

usual to put a stop abutment at every tenth arch, so as to confine any such accident within those limits. The stop abutment is made sufficiently strong to withstand the thrust of an arch or of a series of arches if the next one should fail.

Suspension Bridge Chains. The chains for a suspension bridge take the same shape as the curve of thrust of an ordinary arch, but inverted. If the load be taken as approximately uniform over the span, the curve will be a parabola, and this is generally the case, owing to the excessive weight of the roadway compared with the chains themselves. Moreover, the catenary curve, which is the true shape of a suspended chain, is indistinguishable from a parabola when its dip does not exceed one-tenth of the span. When deeper, the catenary is seen to be nearer to the shape of a circular arc. The catenary is also a difficult curve to draw, while the parabola is very easy.

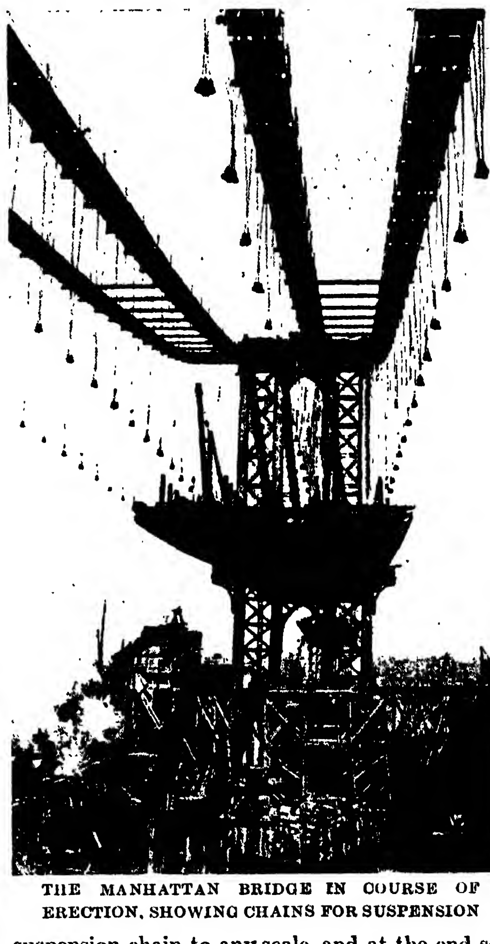
Stresses in Suspension Chain. The stresses in a suspension chain can be shown very readily by a graphic diagram. Let ABC [28] represent the elevation of a suspension chain uniformly loaded throughout the span with a total load AC, then by reciprocal diagram let *ac* [29] equal the line of loads, draw *ad*, *cd*, parallel to tangents to the chain at A and C, then the lengths *ad*, *cd*, will give the stress at points A and C. Similarly, *db* parallel to tangent at B, or *de* parallel to tangent at E, will give the stresses at those points. Allowance may be made for any want of uniformity in the actual loading by setting off upon the load line of the reciprocal diagram the load to be carried at each of the points of attachment.

Effect of Dip in Chain. The effect of reducing the dip or deflection of the chain in increasing the stress may be shown comparatively by diagram **30**, where AB is the span and *dc* the deflection. Then, according to the rule for a parabola, make *ce* equal to *dc*, and join A*e* to give the direction of the tangent to the curve at point A. Complete the enclosing parallelogram AB*fg*, then A*h*, being the tangent, A*f* : load on Ac : : *f h* : stress at *c*, or stress at $c =$ load on Ac $\times \frac{fh}{Af}$. Take point *k* so that *dk* equals half *dc*, then Ac, being the tangent, A*f* : load on Ac : : *fc* : stress at *k*, or stress at $k =$ load on Ac $\times \frac{cf}{Af}$. Again, take point *l* so that *dl* equals half *dk*, then A*g*, being the tangent, A*f* : load on Ac : : *fg* : stress at *l*, or stress at $l =$ load on Ac $\times \frac{fg}{Af}$, from which it will be seen that the general statement may be made of *half the dip, double the stress.*

Stress by Calculation. The tension at the lowest point of the cable follows the same law as the flange stress in the centre of a girder, or the thrust at the centre of an arch—viz., $T = \frac{Wl}{8d}$, where $T =$ tensile stress in tons, $W =$ total load in tons, $l =$ span in feet, and $d =$ dip in feet. The tension at the piers will manifestly be increased by the weight of the chain being suspended from those points. The amount of the tension in the cable at the piers will be given by the formula

$$T = \sqrt{\left(\frac{Wl}{8d}\right) + \left(\frac{W}{2}\right)^2}.$$

Tension in Backstay and Pressure on Pier. The tension in the backstay, or anchor chain, and the pressure on the pier will depend upon the angle at which the former leaves the pier. If it is curved, then the tangent to the curve must be taken as the virtual direction. An illustration is shown in **31.** Let A be the top of pier; set off half the span of suspension chain to any scale, and at the end set off twice the dip to the same scale, and through the point so found draw line AB, which will be the tangent. Let AB equal the tension to any given scale; then, if the cable is free to move over the piers, the tension will be of the same amount in the backstay; therefore draw AC equal to AB, and let AC follow the direction of the tangent to the backstay. Then complete the parallelogram BACD and draw the diagonal, which will give by its length the resultant pressure and its direction upon the pier. HENRY ADAMS



THE MANHATTAN BRIDGE IN COURSE OF ERECTION, SHOWING CHAINS FOR SUSPENSION

The Concluding Part of a Short Study in Modern English Prose, with Notes on the Leading Writers and Their Characteristics.

MORE RECENT PROSE WRITERS

It is not to be denied that in the making of literature the perspective of time is more important to the forming of a lasting estimate than in any of the other arts; but as none but the dry-as-dusts can subsist exclusively on the literature of the past, and contemporary literature must ever be the most widely read, we need make no apology for taking reasonable interest in its creators, and including here references to living authors.

The twentieth century prose men carry forward the literary tradition on lines somewhat different from those that were followed by the writers of even the later part of the previous century. We have seen how the newspaper and the magazine diverted the great eighteenth-century talent for letter-writing into public instead of private channels. We have now to notice how the changes in the newspapers and magazines themselves have modified the style and, to a considerable extent, the point of view of those whom we call the writers of today. Here and there are a few young writers who haunt the old paths, the "bookish" shades, but in the main the essay has become the "article," and the article, as a rule, has a very definite character foreign to the essay proper. This is due in its turn to the progress of that popular movement inaugurated by the first Reform Act and the rise of the newspaper Press. The article is, in other words, the answer to the demand of the people for concise information on subjects which they have had no special opportunity to study.

With the widespread development of education the exclusive and specialised power of the pen passed from the hands of a "literary" class, and the men of letters ceased to be a sort of priesthood. There is no literary "class" today, although vastly more men and women make their livelihood by the pen than in any previous age. There is no literary class, because so many are potentially literary who are content to remain readers. Then, again, those who write for a livelihood must address themselves to the interpretation and solution of what are called "questions of the day," because it is "journalistic interest" that rules. These "questions," it is true, are often literary in a sense, but every writer who now secures any considerable hold upon the public is compelled to recognise that life is greater than literature.

This demand for the "human" as distinct from the "literary" interest in letters has led to a vast increase in the output of fiction. The vogue of the novel has been attended by revolutionary changes in the form of that type of literary work, and has drawn into the service of fiction great numbers of men and women who might, under less competitive conditions, have devoted their gifts and talents to other departments of the literary production. A notable example was found in the case of GEORGE MEREDITH (b. 1828; d. 1909), whose avowedly critical work is represented by one tiny volume, his "Essay on Comedy." Sir JAMES BARRIE (b. 1860) is another whom the novel, and, later, the stage, has claimed, though his miscellaneous writings in literary criticism—not yet, and little likely ever to be, collected into book form—disclose a quite unusual talent for that form of work.

More and more the daily and weekly newspapers and the monthly magazines are likely to become the mediums of circulating the best that living prose has to afford, not only in criticism of life and letters, but in creative fiction also. The book will be merely the convenient secondary condition of the great body of twentieth century prose, for permanent record and reference.

A point to be noted is that the scholar need no longer be a mere creature of the library, living entirely in and for his books, but that he may be equally, or to some extent, a man of the world. This is perhaps the real point of difference between the scholarship of the last century and that of the century in which we are living. The vivifying and humanising influence that comes from participation

in the active life of the world is modifying the work of our prose writers so that less and less in the coming years will it "smell of the lamp." In this respect the prose literature of the twentieth is likely to differ more remarkably from that of nineteenth century than the latter from the prose of the eighteenth. Yet it is no new thing; it is essentially a return to a condition that has obtained at other times in the history of letters.

VISCOUNT (JOHN) MORLEY (b. 1838) is the most typical example in the first quarter of the twentieth century of a man of letters who is also a man of affairs. Though he has held some of the highest offices in the State, he has never surrendered his literary rôle, but from time to time has given reminders, by the quality of speech or article, that in the responsible statesman a craftsman of the first order still keeps his literary ideals undimmed. Before he wrote his *magnum opus*, the "Life of Gladstone," Morley had won a European reputation by his studies of Burke, Voltaire, Rousseau, Diderot, Cobden, Cromwell, and Machiavelli. Though his style is marked by a philosophic severity, caught perhaps from John Stuart Mill, who was his acknowledged master in economics and to some extent in politics, he can on occasion rise to a full-toned eloquence which carries the profoundest thought with grace as well as power.

Recent Historical Writers. Among historical writers who have come into their own since the period we have ended with Stevenson—though some of them have joined the majority—we must mention Lord ROSEBERY (b. 1847), whose Napoleonic studies demand special mention, as do those also of J. HOLLAND ROSE (b. 1855). MARTIN HUME (b. 1847; d. 1910) explored the Spanish and English archives, and added greatly to our knowledge of the Elizabethan period. ALBERT FREDERICK POLLARD (b. 1869) is the uthor of valuable Lives of Cranmer and Henry VIII. GEORGE MACAULAY TREVELYAN (b. 1876) has written studies of the England of Wycliffe and of the Stuarts. JOHN EDWARD COURTENAY BODLEY (b. 1853) is one of the greatest English authorities on modern France. EDWARD DICEY (b. 1832; d. 1911) was an authority on the Balkans and Egypt. ALBERT VENN DICEY (b. 1835) has written valuable works on constitutional law. EDWARD SPENCER BEESLY (b. 1831) is the author of a vivid study of Queen Elizabeth as a "Statesman." To JAMES GAIRDNER (b. 1828; d. 1912) we were indebted for a standard edition of the Paston Letters and for invaluable labours as editor of the Calendar of State Papers of Henry VIII.'s reign. WILLIAM HENRY FITCHETT has done a great deal to popularise the story of the Empire. STANLEY LANE-POOLE (b. 1854), the historian and archæologist, has written voluminously and authoritatively on India and the East generally, and his biographies of Stratford de Redcliffe, Sir Harry Parkes, and many other notable men are works of standard quality. AUGUSTUS JESSOP (b. 1824; d. 1914) wrote admirably of Elizabethen men and movements and of the mediæval Church in England. FRANCIS AIDAN GASQUET (b. 1846) is the most prominent Roman Catholic historian of our day, and a great controversialist. Sir ROBERT K. DOUGLAS (b. 1838; d. 1913) was a notable Orientalist. The work of ALICE SOPHIA AMELIA GREEN merits honourable mention by the side of that of her late husband, of "Short History" fame. JOHN HORACE ROUND (b. 1854) has also made considerable contributions to the sum total of our historical knowledge.

A Group of Scholars. Of writers on classical, philosophical, and economic subjects must be named JOHN PENTLAND MAHAFFY (b. 1839); ARTHUR JAMES BALFOUR (b. 1848), whose "Defence of Philosophic Doubt" and "Foundations of Belief" have awakened much discussion; ALFRED RUSSEL WALLACE (b. 1823; d. 1914); JAMES SULLY (b. 1842); Sir EDWARD BURNETT TYLOR (b. 1832); Sir ARCHIBALD GEIKIE (b. 1835); Sir NORMAN LOCKYER (b. 1836); RICHARD BURDON HALDANE (b. 1856); WILLIAM CUNNINGHAM (b. 1849); and ALFRED MARSHALL (b. 1842); JOHN BEATTIE CROZIER (b. 1849); JOHN ATKINSON HOBSON (b. 1858), and Sir OLIVER LODGE (b. 1851).

Some Theologians and Higher Critics. Leading writers on theology and Biblical criticism include the following: SAMUEL ROLLES DRIVER (b. 1846; d. 1914), THOMAS KELLY CHEYNE (b. 1841), HERBERT HENSLEY HENSON (b. 1863), CHARLES GORE (b. 1853), WILLIAM BOYD CARPENTER (b. 1841), WILLIAM HENRY FREMANTLE (b. 1831), GEORGE ADAM SMITH (b. 1856), STEWART SALMOND (b. 1838), WILLIAM HENRY BENNETT (b. 1855), JAMES HASTINGS, MARCUS DODS (b. 1834), PETER TAYLOR FORSYTH (b. 1848), ANDREW MARTIN FAIRBAIRN (b. 1838; d. 1912), ROBERT FORMAN HORTON (b. 1855), W. F. ADENEY, CUNNINGHAM GEIKIE (b. 1824; d. 1906), and JOSEPH AGAR BEET (b. 1840). The names of ARCHIBALD H. SAYCE (b. 1846), the Assyriologist, WILLIAM MATTHEW FLINDERS PETRIE (b. 1853), the Egyptologist, and ERNEST A. WALLIS BUDGE, perhaps the greatest of living Assyrian and Hebrew scholars and antiquaries, also claim mention here.

Some Famous Editors. When the sum of our knowledge of the Elizabethan dramatists comes to be computed, it will be difficult to over-estimate what we owe to the self-sacrificing labours of A. H. BULLEN (b. 1857). Other leading editors are: ISRAEL GOLLANCZ (b. 1864); Sir HENRY CRAIK (b. 1846); WILLIAM ALDIS WRIGHT; WILLIAM WALTER SKEAT (b. 1835), the Chaucerian scholar; Sir ADOLPHUS WILLIAM WARD (b. 1837), the historian of English dramatic literature; HENRY BENJAMIN WHEATLEY (b. 1838), editor of "Pepys' Diary" and student of the history and celebrities of London; JOHN WESLEY HALES (b. 1836); CHARLES H. HERFORD (b. 1853), whose "Literary Relations of England and Germany in the XVIth Century" opened up new ground for literary research, and at the same time covered the area with remarkable thoroughness; PAGET TOYNBEE (b. 1855), the great authority on

Dante; ERNEST HARTLEY COLERIDGE (b. 1846); ROWLAND E. PROTHERO (b. 1852), the editor of Byron's Letters; GEORGE WALTER PROTHERO (b. 1848), author of "The Life and Times of Simon de Montfort" and other historical works; WILLIAM MICHAEL ROSSETTI (b. 1829), editor of many poets, who has given us a standard edition of the works of his sister Christina; WILLIAM CAREW HAZLITT (b. 1834); WILLIAM PATON KER (b. 1855), whose "Essays on Mediæval Literature" afford a necessary corrective to dithyrambic Elizabethanism; JOHN H. INGRAM (b. 1849), author of an excellent "Life of Edgar Allan Poe," and editor of various editions of Poe's prose and poetry; EDWARD VERRALL LUCAS (b. 1868), the latest and most complete biographer of Charles Lamb, and the compiler of charming anthologies; WILLIAM ARCHER (b. 1856), the translator of Ibsen and a trenchant critic both of literature and the drama; ARTHUR BINGHAM WALKLEY (b. 1855), perhaps the most original of living writers on contemporary drama; GEORGE ATHERTON AITKEN (b. 1860), the biographer of Steele and the editor of the best edition of "The Spectator"; EDMUND KERCHEVER CHAMBERS (b. 1866), author of a valuable work on "The Mediæval Stage"; THOMAS WRIGHT (b. 1859), the authority on Cowper; STEPHEN GWYNN (b. 1864), a leader of "the Celtic Renaissance"; ARTHUR SYMONS (b. 1865), one of the most versatile of writers; G. S. STREET (b. 1867), a graceful essayist; CHARLES WHIBLEY, author of "A Book of Scoundrels"; EDWARD ARBER (d. 1913), whose reprints are almost as famous as they are valuable; SIDNEY COLVIN (b. 1845), whose "Life of Landor," "Letters of Keats," and "Letters of Stevenson" are notable; HILAIRE BELLOC (b. 1870), a Roman Catholic writer, whose "Path to Rome" and "The Old Road" are of special value; THOMAS SECCOMBE (b. 1866), author of several excellent histories of literary periods and a competent editor; ARTHUR WAUGH (b. 1866), editor of Dickens, Milton, Tennyson, and Johnson, and critic of general literature; GEORGE WYNDHAM (b. 1863; d. 1913), whose edition of Shakespeare's "Sonnets" is distinguished by an introduction that merits more attention than it has yet received; Sir FRANK T. MARZIALS (b. 1840; d. 1912); and last, but not least, Sir SIDNEY LEE (b. 1859), whose "Life of Shakespeare" may be said to sum up all that is known of the career of the national poet, and whose "Life of Queen Victoria" is another luminous and frank summary of carefully digested data.

A Course of Study in Contemporary Prose. To begin with HISTORY, there are two works which the student will do well to have on his bookshelves. One is Haydn's "Dictionary of Dates" (Ward, Lock), and the other "A Handbook of European History, 476–1871, Chronologically Arranged," by Arthur Hassall, M.A. (Macmillan, 1897).

A good grounding in modern European history will be gained by a study of Sir Theodore Martin's "Life of the Prince Consort," Sir Sidney Lee's "Life of Queen Victoria" (Smith, Elder), Justin McCarthy's "History of the Four Georges and of William IV." and "History of Our Own Times, from the Accession of Queen Victoria to 1897" (Chatto & Windus), and Viscount Morley's "Life of Gladstone" (Macmillan). All of these works are as delightful to read as they are informative. For the study of Greater Britain we commend "A Short History of the Expansion of the British Empire, 1500–1870," by William Harrison Woodward (Cambridge University Press); "Problems of Greater Britain," by Sir Charles Dilke (Macmillan); and Sir A. C. Lyall's "Asiatic Studies," "Rise of the British Dominion in India" (Murray), and the "Rulers of India Series" (Oxford University Press). We would commend also Mr. J. E. C. Bodley's "France" (Macmillan) and the "Journals" of the Royal Colonial Institute and Society of Arts.

Literary Biography, History, and Criticism. There is no more interesting and valuable biography for the literary student than the memoir of Tennyson, by his son. Next to this we should place "The Letters of Robert Browning and Elizabeth Barrett," edited by R. B. Browning (Smith, Elder). A valuable handbook is Mr. Frederick Ryland's "Chronological Outlines of English Literature," from the year 600 to 1899 (Macmillan, 1890). Of Dr. Georg Brandes' "Main Currents of the Literature of the Nineteenth Century" and M. Frédéric Loliée's "History of Comparative Literature" sound translations have been published by Messrs. Heinemann and Hodder & Stoughton respectively. Professor Saintsbury's "Loci Critici" contains a series of passages illustrative of critical theory and practice from the time of Aristotle to the day of Matthew Arnold. It is published by Messrs. Ginn. Other works of value are "Principles of Criticism" (Allen) and "Judgment in Literature" (Dent), by Basil W. Worsfold; "Studies in Literature" (Kegan, Paul), by the late Professor Dowden; the "Miscellanies" (Macmillan) of Viscount Morley; "Questions at Issue" (Murray), by Edmund Gosse; the "Obiter Dicta," and its companion volumes (Elliot Stock), by Augustine Birrell; and the "Studies in Two Literatures" (Heinemann), by Arthur Symons. More recent biographical works reaching a very high standard of workmanship are the "Life of John Ruskin" and the "Life of Florence Nightingale," both by Sir Edward Tyas Cook.

Greek and Latin. The late Professor S. H. Butcher's "Aspects of the Greek Genius," Professor Gilbert Murray's "Ancient Greek Literature," and Professor J. W. Mackail's "Latin Literature" are works that are among the best of their kind.

Continental Literature. Dowden's "History of French Literature" and the other volumes in Heinemann's "Short Histories of the Literatures of the World" are commended.

The student of philosophy and religion should consult the works the titles of which, in any good biographical handbook, are attached to the names of the writers referred to in our list of the leading representative writers of the day.

J. A. HAMMERTON

The Biggest Government Department. Employment in London and the Provinces for Learners, Sorters, Clerks, Postmen, and Messengers.

THE POST OFFICE SERVICE

The Postmaster-General is the greatest employer of labour in the kingdom. The staff of which he is the official head numbers in all over 200,000 persons, of whom about one-fourth are women. This giant force includes both established Civil servants, male and female, and an unestablished section comprising messenger boys, supernumerary postmen, temporary officers, and others whose terms of employment do not confer any right to a pension.

There is scant use in enlarging upon the variety and volume of work performed by the Post Office in all its ramifications, extending from the village shop counter, where stamps are retailed, to the huge headquarters of the department, which are among the show places of our capital.

The Amazing Growth of the Post Office. Of greater practical importance is the fact that for a century, at least, this monster department has grown with amazing speed. The evolution of railways, the introduction of penny postage, the acquirement in 1870 of virtually all telegraphic systems, and the incorporation, as recently as 1912, of the London Exchange area of the National Telephone Company, with its staff of some 15,000 employees, have marked the most striking stages in a development that has been practically continuous throughout.

Despite the cheapness and efficiency that characterise Post Office work, the great national service, far from being a charge upon the country, produces an annual profit of between four and six millions sterling.

Two outstanding features of this giant department call for notice. It is the most democratic among Government offices in providing ladders by which merit may rise from grade to grade, and it makes more complete provision for the future of its young workers than almost any other employer of boy labour.

Women as Post Office Servants. The Post Office service is distinguished also from all other Government offices by the great number of females it employs. In district branches much of the counter and telegraph work is performed by girls and women; the Central Telegraph Office provides occupation for more than a thousand female telegraphists; there are upwards of four thousand telephonists on the staff of the London telephone service; and other sections of the headquarters possess a strong contingent of girl clerks and sorters.

Women engaged on the establishment of the General Post Office—as in other State departments—are under the same general rules, and are entitled to pensions on exactly the same scale, as their masculine colleagues. They are subject, however, to one important disability. Except in the case of the postmistresses, who are specially exempted, female officials must be unmarried or widows, and they are required to resign their appointments on marriage.

In that event, happily, the service which otherwise would count towards a pension does not go entirely unrecognised. Women who have served for not less than six years receive, when quitting the service in order to be married, a special Treasury gratuity. The amount of this wedding gift is fixed at one month's pay for every completed year's employment up to a maximum of twelve years. A clerk earning, for instance, £84 a year would be entitled after six years' service to a marriage gratuity of £42, after nine years to £63, and after twelve years to £84.

A candidate for a permanent appointment on the Postmaster-General's feminine staff—whether in London or otherwise—must be at least 5 ft. in height. She is generally required, also, to reside either with her parents or guardians or with friends of whom they approve.

London and Provincial Services. The general staff of the Post Office, in all large towns as well as in the metropolis, is largely recruited by the appointment of learners of either sex, who are trained in telegraphy and counter duties. The London service includes also a number of male and female sorters attached to the central and district offices. It should be specially noted that in respect of each of these grades, three distinct methods of making appointments are adopted. The first and most important is that of open competition. For the others the nomination of the Postmaster-General is essential, the candidates approved by him competing among themselves for vacancies or having merely to pass a test of efficiency. During recent years there has been an increasing tendency to reserve both learnerships and sorterships for limited competition among approved candidates, and especially among those already serving in the Post Office. Boy messengers, in particular, have excellent chances of winning such posts, and aspirants will hardly need to be reminded that the wicket-door of nomination is an easier means of entrance than the thronged gateway of a public contest.

Those readers who are not already postal servants, and who desire nominations for the posts of learner and sorter, may be interested to learn that private influence with the Postmaster-General is not essential. The likeliest method of succeeding is to enlist the good offices of the district postmaster or other official on whose staff the coveted vacancy arises. For candidates who are unable to secure a nomination the public contests are always available.

The Examination for Learners. Competitions for these berths are held once or twice yearly, in London and at each provincial town where vacancies exist or are expected. The conditions of duty for London learners and their rates of pay differ slightly from those obtaining in provincial offices, but the examination subjects are identical. Indeed, for all learnerships throughout the Post Office service—whatever the sex of the candidate or the mode of filling appointments—a single examination scheme is prescribed by the authorities. It is of the simplest character, comprising only the following three branches:

1. English composition, including writing and spelling.
2. Arithmetic. English and metrical weights and measures, reduction, vulgar and decimal fractions (excluding recurring decimals).
3. General geography, with special reference to the British Isles.

A total of at least half marks is necessary in order to qualify.

Male Learners. The same standard of height—namely, 5 ft.—is fixed for these officers as for female Post Office servants, but by a curious regulation male learners are further notified that they will not be retained in the service unless they reach 5 ft. 4 in. by the age of 19. In London, where the system of open competition is entirely suspended for the present, candidates must be between the ages of 15 and 18. In the provinces, limited contests between lads of 15 and 17 are the rule, but occasional examinations open to anyone within the limits of 14 and 16 are held when the supply of nominated candidates is small.

The London Staff. Successful candidates attend for eight hours daily, receive instruction in telegraphy and afterwards in counter duties during about a year, and are paid 8s. a week meantime. While under tuition their engagement may be cancelled if they show no proper aptitude for the work. They are liable to do Sunday work and sorting duties, and on reaching the age of 18 will be called upon to do night-work when requisite. As vacancies occur, proficient learners are appointed to the established staff at a salary of 18s. a week, either as telegraphists at the Central Telegraph Office or as counter clerks and telegraphists in the London postal service, from which moment their service begins to count towards a pension. At the age of 18 their weekly pay is increased to £1. From that figure it rises every year by increments varying between 2s. and 4s. a week up to 44s. a week. An officer who obtains "a certificate of excellence of conduct and ability to perform the highest duties of his class" continues to advance to the maximum of 65s.

In both branches of the London service these officers are eligible for promotion to certain higher appointments, relatively few in number, ranging from the grade of overseer, at £180 a year, up to that of inspector or superintendent, with a salary of £350 or £400.

Provincial Posts. Male learners in provincial centres are trained much as in the London service, but their wages, both before and after promotion to the establishment, vary slightly in the different towns, and are generally rather less than in the capital. Beginning at 6s. a week, and rising to 9s. when efficient at telegraphy, and 14s. next year, they become sorting clerks and telegraphists as vacancies occur. At the age of 18 their pay is 17s. a week, and in certain towns 18s. Thence it progresses each year by 2s. weekly or more to 39s. 6d. or 41s. 6d.; and, if a certificate of conduct and ability is obtained, to a maximum of 48s. to 56s. a week, according to the size of the town. Meritorious officers have also good chances of advancement to the positions of assistant-controller, superintendent, and provincial postmaster, with remuneration varying from £180 to £600 a year.

Female Learners. The examination scheme for these posts being the same as those for men, and the general conditions of service very closely similar, a few words will suffice for such differences in respect of age, pay, and other matters as call for comment.

In all limited competitions the age is fixed at 15 to 17, but at open contests for the London service it is 14 to 17, and for the provincial services 15 to 18. Open competitions for vacancies as female learners have lately been held twice yearly, and are very keenly contested as a rule.

Except that women, while liable for Sunday duty, are not called upon to perform night-work, the mode of instruction and hours of duty are the same for female as for male officers, but the rates of pay, although they have been recently improved, are still a good deal less. Female learners in the London branch are paid 7s. a week on entry, and 10s. 6d. when certified as competent for telegraph instrument duty. After a year's service at this figure, if still less than 18 years old, they receive 14s. weekly. They are promoted to the established class as vacancies arise, and then receive 16s. a week if less than 18 years old. By a special provision of the Postmaster-General, every member of the London service, whether promoted or not, receives from her eighteenth birthday the "age pay" of 18s. a week. From that salary, established clerks advance by annual increments of 2s. weekly to 30s., and, on obtaining a certificate of proficiency, by 1s. yearly to 40s. a week. They are also eligible for higher posts at £130 a year and upwards, but these are few.

In provincial towns slightly lower rates prevail both for learners and for established clerks. The salary appointed by the regulations for officials of either class on their reaching the age of 18 is 15s. or, in some cases, 14s. weekly. Officers on the establishment receive, as in London, annual advances of 2s. and 1s. a week, but the maximum attainable varies between 32s. and 36s. There are also further possibilities in the way of superintending positions and

appointments as postmistress, few of them exceeding in value £200 a year.

Male Sorters. Vacancies arising in the ranks of the male sorters are now regularly reserved for limited competition among postmen, telegraph messengers, and other subordinate members of the London and provincial Post Office staff. They must be nominated to compete by the heads of their departments, and in this way promotion is given to deserving and intelligent officers. The system of open examinations is suspended meanwhile, but may be resumed.

Candidates must be between 18 and 25 (in London 30) years of age. They must be at least 5 ft. 4 in. in height, and physically fit for the proper discharge of their duties. Apart from specific ailments, constitutional weakness or want of general vigour may disqualify a candidate from receiving an appointment. The examination subjects are precisely the same as for Post Office learners, given above.

Pay and Duties. London sorters are paid 20s. a week when appointed, and advance, just as ex-learners do, to 44s. a week, officers who are certified as fully proficient going on to the special maximum of 65s. Provincial rates are slightly lower. There are also a moderate number of higher positions rising to £200 and £290 a year.

These officers are on probation for the first year, and are employed chiefly in letter sorting, in which subject they must pass a test within a few months after being appointed. They do eight hours' duty daily, sometimes beginning early in the morning or late at night. Sunday work counts as extra duty, and is paid for at special rates.

One of the special privileges of messenger boys in the Post Office is that they may compete among themselves for most of the vacancies occurring among sorters, but a certain number of these openings are reserved for meritorious postmen and other adult postal servants.

Female Sorters. About 1000 female sorters are employed in various departments of the London General Post Office. Their duties relate, not to letter sorting, but to arranging vouchers and counterfoils for the clerical staff. They work for the same number of hours as their male colleagues, but under less trying conditions, being engaged only between eight in the morning and five in the afternoon; and they are exempt from Sunday duty. The wages paid begin at 14s. weekly, and rise by 1s. a week for two years, and afterwards by 2s. to 30s. a week, subject to a special certificate of ability when 22s. is reached. There are chances of promotion to the rank of assistant clerk (described on the next page), but with this exception there is little scope beyond the 30s. maximum prescribed for sorters.

The age limits for these situations are 15 and 18, and it will be seen that they are approximately of the same value as London learnerships—at least, during the earlier years of service. But the work is more monotonous and uninteresting, the maximum attainable is 10s. a week less, and there are very few higher posts for which sorters are eligible. Further, the examination, simple as it is, comprises the learners' subjects and an extra one besides—that of reading and copying manuscript. Apparently, however, these objections are more than outweighed by the certainty of fair and progressive earnings from the outset, instead of the learner's small allowances and her uncertain chances of a vacancy on the establishment. The result is that the open contests for female sorterships—held, as a rule, each May and December—are thronged with candidates in the ratio of a dozen or a score to every vacancy, and the proportion of marks necessary for success rises sometimes to almost 90 per cent.

Female Clerks. Just a generation has elapsed since a former Postmaster-General decided to admit a few women clerks to the ranks of his headquarters staff. So successful did the venture prove that today, apart from those who have entered as learners, there are some 2850 women employed at the G.P.O. on a special clerical footing. Of this number, about 2600 hold permanent positions as women clerks, the remainder being temporary girl clerks.

Unlike learners, members of these two classes are never called upon to do duty in the local post offices, nor, indeed, to come into contact with the general public in any way. They are employed in a private and strictly clerical capacity in certain of the central departments—chiefly in the Savings Bank. Among the attractions of the service are short hours of duty, pleasant work, and an assured prospect of at least £110 a year.

The senior and the junior grade are separately recruited by means of open competition, but

OPEN COMPETITION FOR GIRL CLERKS AND WOMEN CLERKS

Order of Merit	English Composition (including Spelling)	Handwriting	Arithmetic	Geography	Précis Writing	Two only, including at least one language: Latin	French	German	English History	Mathematics	Total
Maximum	500	300	600	500	300	500	500	500	500	500	3200
Girl Clerks: ..											
No. 1	380	281	479	354	225	412	371	—	—	—	2502
No. 80	355	263	490	283	135	—	395	—	267	—	2188
Women Clerks:											
No. 1	352	300	500	338	200	—	348	—	—	435	2473
No. 105	258	289	404	213	170	328	—	—	—	335	1997

the examinations for both classes are held simultaneously, the subjects prescribed are the same, and, in fact, the papers set are identical for each, though the lists of candidates and the results are kept entirely distinct. As a rule, contests for both girl clerks and women clerks are held twice yearly—in April and October. In order to qualify, half marks must be obtained.

Examination Subjects. The schedule given on the previous page relates to the most recent of these dual competitions whose results have been published. It shows the marks secured by the highest and lowest successful candidate in the women's and the girls' section.

A few words may be added as to the character of the examination. The paper in geography is always largely concerned with the physical and industrial aspects of that study, and generally includes the insertion of details in a printed outline map, and several questions on the natural wealth and manufactured products of various countries or districts. The modern language tests comprise dictation, easy composition, and translation from and into the foreign tongue.

Girl Clerks. Appointments of this class are in themselves of a temporary nature, and are intended to furnish suitable training for the senior and permanent grade. The examinations are restricted to girls between 16 and 18 years of age. Some 40 to 80 vacancies are offered at each examination, and though the number competing is sometimes ten times as great, the *effective* competition is smaller, as often less than half the candidates reach the qualifying standard.

Girl clerks are employed as such for a term of only about two years, performing seven hours' duty daily, and receiving £42 the first year and £45 the next. At the end of that time, those who are certified as competent are promoted, as vacancies occur, to be women clerks. Girls who fail to obtain a certificate of competency are appointed as female sorters, retaining their current salary. For a clerk of ordinary intelligence and application, however, advancement to the senior grade should be a matter of course.

Women Clerks. The age limits for these posts are 18 and 20, and therefore a student who reaches the former age without having gained a girl clerkship can transfer her efforts to the senior grade without the slightest loss of time or change of work.

Women clerks are required to do seven hours' duty daily. On entering the service they are appointed to the second class at £65 a year, and receive annual rises of £5 to £110. On promotion to the first class the salary becomes £115, rising by £5 to £140. Beyond this class there are a few higher positions, culminating in that of superintendent at £280 a year, advancing to £450 or £500. Thanks to the way in which the ranks are depleted by marriage, a first-class clerkship at least may be anticipated by those who remain in the service.

At one time these posts were keenly contested, but for some reason—possibly connected with the advent of the typewriter and the consequent increased demand for women clerks in the commercial world—the number of candidates has been steadily declining of late. The contest of which particulars are given above was attended by only 324 women. These figures may be commended to the notice of young women in search of an easy and settled calling.

Women Assistant Clerks. A new clerical grade, intermediate between women clerks and female sorters, was recently established by the Postmaster-General. These officers, who are known as women assistant clerks, are employed chiefly in the money order department and the London telephone service. Their duties consist mainly in "examining" postal orders and pension orders—comparing the documents with book entries—and in registering the receipt and disposal of official papers. The scale of salary is 18s. a week, increasing by 1s. yearly to 20s., and then by 2s. to 34s.

It was originally intended that this service should be recruited by competitive examination, but hitherto all vacancies have been filled by the promotion of women sorters, and there is at present no indication of a change of method.

Telephonists. The Post Office telephone service gives employment to a large number of women officially styled telephonists. In the London telephone service no fewer than 4216 of these officers are engaged. They are paid 7s. a week when appointed as learners. On their becoming efficient operators, their wages, starting at 11s. weekly, become 14s. after the first year, and advance in the next nine years to 28s. a week. In the provinces a competent operator begins at 10s. and rise to 26s.

The nomination of the Postmaster-General, which is required for these situations, is readily given to suitable candidates between the ages of 16 and 19. A simple and non-competitive test in reading and copying manuscript, writing, spelling, and the first four rules of arithmetic must then be passed. Finally, applicants must satisfy the authorities that they are medically fit, are free from hysteria or excessive nervousness, and have neither impediment of speech nor strongly marked accent that might prevent their being readily understood over the wires. It may be added that to women of highly strung nerves the operator's life, with its perpetual liability to sudden calls, is peculiarly trying.

Women Typists. In most departments of the General Post Office there is a small typewriting staff, which is recruited by means of half-yearly examinations open to all single or widowed women between the ages of 18 and 30. The subjects prescribed are six in number: writing, spelling, English composition, copying manuscript, simple arithmetic, and—at a later date—typewriting. Only those candidates who have gained good marks in the first five subjects are permitted to take the sixth.

The typewriting test consists of copying two documents—a straightforward passage and a tabular statement. Moderate speed is essential, competitors being expected to type 500 words of the first paper in half an hour. On the other

hand, no extra marks are gained by typing more than 800 words in that time. Good general display, touch, and the suitable arrangement of tabular matter are also important.

Although the competition for these posts is usually very keen, they cannot be said to compare favourably with commercial positions of the same class. A Post Office typist is paid £1 for a week of 42 hours, and receives a yearly increment of 2s. up to 26s. If qualified also in shorthand she may proceed to a maximum of 31s., but beyond this she cannot hope to go.

Junior Clerks. A number of junior or third-class male clerkships in the General Post Office are reserved for competition among established officers who have served for at least two years in that department, and are between 19 and 26 years of age. In order to obtain the requisite nomination of the Postmaster-General such officers must be specially recommended by their chiefs as fitted for clerical duties.

The appointments in question arise in various branches of the central office, and are not of uniform value, but they are all sufficiently attractive in respect of increments and prospects to be worth the attention of eligible sorters, telegraphists, and subordinate officers of similar rank. In the secretary's office they begin at £100, and rise by £10 yearly to £250, with an excellent prospect of £350 and chances beyond. In most of the other departments third-class clerks start at £100 a year, and progress by increments of £7 10s. to £130, and then of £10 to £200, with further possibilities about equal to those afforded by the secretary's branch.

A score or more of these posts are usually contested each March and September. As deserving officers are nominated with some freedom, the number of candidates for each vacancy has been, in one instance at least, as many as 14, but is usually about half that number. The examination is in English composition (with writing and spelling), arithmetic, geography, two languages (the choice being among French, German, and Latin), and two of the following subjects—English history, mathematics, and shorthand.

Postmen. For the London and the provincial service alike postmen are nominated singly by the Postmaster-General, and have to pass only the simplest of qualifying examinations—which is dispensed with in the case of candidates holding second-class Army certificates. For other entrants the subjects are writing, addition, and reading and copying a number of lithographed postal addresses of very moderate difficulty. The limits of age are 18 and 30, but the upper limit is extended to 35 for entrants who have served 12 years in the Army or Navy, and to 45 for those who are receiving a pension.

London postmen number 10,167, and there are about 50,000 in the provincial service. The wages paid in the metropolitan area begin at 19s., and rise generally to 35s. a week, with stripe allowances varying from 1s. to 6s. weekly—according to length of approved service—and a boot allowance of 21s. a year. There are also a few senior and head positions beginning at 41s. and rising to 62s. a week. In provincial offices the rates of payment vary widely, according to the area served and the duties performed, but are generally lower than in London, and the proportion of head positions is relatively less. At Edinburgh and Dublin, for example, the pay of postmen rises to a maximum of only 30s. instead of 41s. Further advantages of the London service are the chances it affords to competent officers of securing nominations for sorterships and junior clerkships in the G.P.O.

Boy Messengers. The Postmaster-General has contrived to find permanent employ for a greater proportion each year of the telegraph messengers who have reached the upper limit of age for their work. Today there are openings for every messenger boy who is qualified to take advantage of them. An intelligent lad leaving an elementary school at 14 or thereabouts has thus every prospect of regular and well-paid work for life if he enters the Post Office service.

Alike for the London and the provincial offices, candidates for employment as boy messengers must be under 14½ years of age and not less than 4 ft. 8 in. in height without boots, and should have passed Standard VII. If their record is good they are engaged as vacancies arise, no entrance examination being necessary.

The wages vary somewhat, being in some instances dependent on the number of messages delivered. In London they are not less than 7s. a week, rising by 1s. yearly to 11s., and uniform (including boots) is always supplied free. The hours of duty average 50 weekly.

Examination for Permanent Posts. Boy messengers must attend educational classes for four hours a week at least, to fit themselves for adult employment later, in the Post Office or elsewhere. Every half-year a general competitive examination in writing, spelling, English, arithmetic, geography, and history is held among those who are nearing the upper limit of age, and a large proportion of them are given permanent posts on the results of the competition. Most of the boys selected become assistant postmen, and eventually postmen, no less than half the vacancies in these branches being reserved for them. The more intelligent and better educated lads compete among themselves for the situations of learner, sorter, and clerical assistant, the last beginning at 16s. a week and rising to 56s.

Boys who do well in the general examination are also given the option of going through a course of training to fit them either for the engineering department of the Post Office or for the Royal Engineers. Those who wish to enter the Army or Navy are retained as messengers until 19, and are entitled to return to Post Office employment when their service expires, if their health and character are satisfactory. Half the vacancies in the wireless telegraphy branch of the Navy are reserved for boy messengers. And for the benefit of those lads not otherwise provided, for an employment register is kept by the Post Office authorities, and consulted by many employers of labour.

ERNEST A. CARR

How the Pea has Thrown Light on the Study of Heredity. Mendel's Law. Dominant and Recessive Characters.

MENDEL AND HIS WORK

In two chapters, with a strange and disastrous gap between them, we must now study the work of a contemporary of Charles Darwin, who died without hearing his name. Johann Mendel was only thirteen years younger than Darwin, being born in Silesia in 1822—the same year as Pasteur and Galton. The boy's father, a small peasant proprietor, was interested in botany, and taught him how to observe the lives of plants.

He learnt quickly and well, and in 1847 was ordained a priest, assuming the religious name of Gregor. This was at Brünn, and there Mendel passed the rest of his life, except for a visit to Vienna, where he studied science. Teaching was in his family, and he taught so well that this was his monastic work until he was appointed abbot of the monastery of Brünn in 1868—a calamity for science.

Mendel's Early Experiments. The young monk had hitherto enjoyed much leisure, which he devoted to botanical and zoological observation. He had the great garden of the cloister at his disposal, and into it he introduced many new plants in order to study their behaviour. Heredity, rather than the effects of nurture upon growth, was his special interest. Especially was he concerned to study the results of mating individuals who were conspicuously different in their personal characteristics. When such individuals are mated, the offspring are often called hybrids; and we may well believe that Mendel was not the first to make experiments in hybridisation, which obviously holds out large and strange possibilities. The more were such experiments to be followed seeing that the doctrine of the immutability of species was seriously threatened, and the mating of contrasted forms might be expected to throw some light on the central problem of the "origin of species."

The Rule that Mendel Disproved. Such experiments, though easily carried out, especially among plants, had been very disappointing, so far as any contribution to the theory of organic evolution was concerned. The results were so variable that nothing could be clearly inferred from them. More serious still, the evidence suggested that hybridisation was an extremely artificial process, against which Nature seemed to guard, so that any results which man might obtain by artificial mating did not really help us with the natural problem.

Lastly, there was the supposed very general and important rule that *hybrids are sterile*. Thus, though a new type of individual might be formed by hybridisation, no new species could come into existence, for the simple reason that the race stopped short at once with the hybrids in question. If more were wanted, they must be produced anew by the original process. Clearly, if all hybrids are sterile, the problem of the origin of species is not contributed to; and we seem to see a kind of natural ordinance forbidding the intermingling of species, and commanding that they shall remain immutable and separate from age to age. It should be added here that this doctrine of the sterility of hybrids is now known to have been greatly overstated, if, indeed, it has any natural and inevitable basis at all.

The foregoing paragraph helps us to understand much about Mendel's work. Clearly he was not satisfied with existing doctrine. He was prepared to devote years of labour, of the most arduous and wearisome kind, to hybridisation experiments, notwithstanding the accepted opinion about them. So much for the quality of the man. But, further, the very nature of his experiments involved their neglect by his contemporaries. To several of these, though not to the greatest, he sent his work, but they were all indifferent to it. Nothing worthy of mention, they thought, could come from this line of inquiry. But the history of science has shown, over and over again, that the man who works at the neglected place, shaping the discarded block, may find it become the headstone of the corner.

Mendel's Many Activities. Mendel worked at many things, not unworthy of note before we proceed to the great study which now makes him famous. He studied sun-spots and the weather, and it is known that he did much work upon heredity in bees. These insects are of peculiar interest for the student of heredity, seeing that different sexes of offspring are produced according as the ova are fertilised by male cells or not. Further, there are many types of bee, well differentiated; and there are large possibilities in the direction of improving the yield of honey, and also of removing the power to sting. Mendel had fifty hives in the cloister garden, and collected and studied queen bees from all parts of the world. Nothing whatever remains, of all his labours, but the empty hives which he used more than half a century ago. It is probable that he destroyed all his notes before his death, at a time when he was terribly depressed in mind and body. Here is another great loss to science, which is only now being slowly repaired.

The Pea as a Study. But Mendel's chief known work was in heredity among plants—though what the result of his observations upon animals may have been we shall never know [see page 1756]. The plant which he chiefly studied was the familiar edible pea. He observed the facts of heredity in that form of plant during the eight years of his life which really matter for us, and read his now classic paper before the Philosophical Society of Brünn in 1865. At intervals

during the next few years further papers of his were read, but very soon after Mendel's appointment as abbot of the monastery his scientific work came to an end.

Indifference to Discoveries. The all-important paper on the pea was duly published in the journal of the society before which it was read, and copies of it are known to have been sent to the leading scientific societies of the world, in the usual way. But Brünn was not a centre of science, and the transactions of local societies are not always of universal interest. It is practically certain that no one, in London or elsewhere, read the paper at all. Had a single student done so, in any capital in the world, his interest must have been aroused, for the results which Mendel had obtained were unprecedented and remarkable. Yet the fact remains that, even where notable men were written to by Mendel himself, they took no notice of his work.

We shall never be able to understand why Mendel, when still interested in his own work, and writing to other students, did not write to Darwin. All the world heard what happened when another worker wrote to Darwin in 1858. Alfred Russel Wallace's paper was at once read, appreciated, and, as soon as possible, given the widest publicity, though its arrival prejudiced Darwin's claim to priority with a theory which he had, in fact, framed long years before. In 1859, the "Origin" appeared. It is recorded that Mendel once remarked that Darwin's theory did not suffice to account for the facts, but he failed to send a copy of his paper to Darwin at the very time when the whole world was in a tumult of excitement over Darwin's theory, and when Mendel's paper was, in fact, the one really substantial and significant new contribution to the discussion that was anywhere in existence. But no one knew that exact and momentous knowledge of heredity, upon which, as we have already insisted, all theories of organic evolution must depend, had been obtained by an obscure monk in Silesia; and the history of biology during the past half-century has accordingly been far other and far less than it would and should have been.

The Close of Mendel's Life. The rest of Mendel's life can only too easily be told. When appointed abbot, he hoped that more time for scientific work would be available. Fate willed otherwise. The dogged determination without which his eight years of work in breeding and counting scores of thousands of peas would have been impossible showed itself in a tragic form. Here is the account of the facts, given by Professor Bateson, the leader of Mendelism today:

"In 1872 the Government passed a law imposing special taxes on the property of religious houses. This enactment Mendel conceived to be unjust, and he decided to resist, claiming that all citizens should be equal in law, and that, if these taxes were imposed on one class of institution they should be imposed on all. He thus took up a position which in England we should call that of a 'passive resister.' At first several monasteries stood out with the Königskloster, but gradually they conformed, Mendel alone remaining firm. . . . The property of the house was eventually distrained upon, but he did not give in. He became also involved in the racial controversies which are often rife in this part of Austria, and it is only too certain that the last ten years of his life were passed in disappointment and bitterness. From being a cheerful, friendly man he became suspicious and misanthropic."

Whether or not Mendel was right, it is a fact that, shortly after his death, the tax was removed. Probably the disease from which he suffered helped to embitter his mind. In 1882 Darwin died, and in 1884 Mendel followed him, after long ill-health, which, as we have seen, probably involved the destruction of some invaluable records.

Not until 1900 did the new epoch begin, with the discovery and development of Mendel's discovery, to which our next chapter must be devoted. Here our business is to note Mendel's method, upon which his success depended, and which is now being followed by observers all over the world, and carefully to study his results, embodied in what is now generally known as *Mendel's law*.

Mating Tall and Dwarf Peas. Mendel began by mating individuals which were sharply contrasted in respect of certain features. Little more than this is the basis for the assertion that his work was merely concerned with some curiosities of hybridisation. The offspring of varieties of peas are, in fact, not hybrids; and the very term "hybrid" ceases to have a meaning as soon as we appreciate the meaning of Mendel's work, and realise that it is impossible to define the term "species" at all, or to distinguish between species and varieties. Taking individuals thus contrasted, Mendel mated them, and noted the characteristics of the offspring.

The typical case is that of the two kinds of pea, one of which is tall, and the other a dwarf about as many inches high as the other has feet. What was proved for this pair of contrasted characters was similarly proved by Mendel for some half-dozen other pairs of characters in the pea, and, in the same manner, for another plant.

The Next Stage of Inquiry. The next, and most essential, step was not to be content with the comparison between the parents and their offspring, but to mate those offspring, technically known as the *first filial generation*, among themselves, and to note the characteristics of *their* offspring, who constitute the *second filial generation*.

The inquiry must be directed solely to the pair of characters under observation. When other characters are to be studied, they must be similarly observed. There is a marked degree of independence, as well as of interdependence, among the *factors*, as we shall learn to call them, which make the living being; and our task of discovering any exact law of inheritance is hopeless unless we keep this in mind, and study one pair of characters at a time.

Three Generations under Observation. At least equally important is the fact that Mendel studied always at least three generations. All inquiries made into the inheritance of particular characters, in any species, which confine themselves to the comparison of parents and offspring must be set aside as incomplete. In all such cases we require a complete record of the second filial generation also before we have enough material to form any conclusions upon.

That is one of the cardinal reforms in genetic inquiry which we owe to the patience and thoroughness of Mendel, and it furnishes the condemnation of a great deal of so-called research in heredity which has persisted in ignoring Mendel's experience, and in basing supposed laws of heredity upon comparison between parents and immediate offspring only.

Mendel's Precautions. A long-familiar fact of heredity should have sufficed to warn observers that only the record of three consecutive generations could suffice as data for genetic inferences. It has long been noticed that features sometimes "skip a generation," as we say, so that a child resembles a grandparent in some character which the parent does not show at all. Yet, of course, that character must somehow have been transmitted through or by the parent, in whom it was therefore latent. Clearly such cases must not be looked upon as freaks or eccentricities on the part of the so-called "force of heredity." Clearly, also, we must study the third generation in every case, for in it we may find the reappearance of striking characteristics which were absent from the individuals of the first filial generation, and of which, if our study had ended with them, we should say that they were not inherited.

This was exactly what Mendel regularly found, thanks to the fact that his method was the right one: certain types of inherited characters, technically called "recessives," *must* disappear in the first filial generation, under certain conditions, and must as surely reappear in the second.

Three Generations Kept Apart. Essential, further, to Mendel's success, as to that of all who are now working on his lines, was the fact that he never mated individuals of one generation with those of another. He scrupulously kept the generations apart, mating only individuals of the same generation; and, finally, finding that, in certain circumstances, different types of individuals are produced, he *counted* the individuals of each kind in each generation. Trying to imagine the needs imposed by the fact that he did not begin with the clue which, thanks to him, we now have, we can realise that eight years were needed for the simple discovery which he made. But it is also to be added that, without his method, neither eight nor eighty years would have found the facts. Many other men have devoted years of honest research to the study of heredity fruitlessly because they did not observe the precautions which, as we have seen, Mendel never forgot. And now let us see his results.

Results of the First Mating. When the tall and short peas were mated, all the offspring were always tall—as tall as the tall parent. That fact, in itself, is remarkable. It is not what we should expect. In such a case, we should look for "blended inheritance," and expect to find the offspring about three feet high—a compromise between the statures of their parents. Such a compromise is what we seem to find when dark and white skinned races of mankind are mated. But in the case of these peas it looked as if the tallness was inherited and the shortness was not. The sex of the tall and short parents respectively did not alter the result. There are now known to be important cases where sex complicates the problem.

Remarkable Results of the Continued Experiment. The next task was to mate these all-tall members of the first filial generation with each other. Had they been tall plants of the normal kind, with nothing but tallness in their ancestry, of course all the offspring would have been tall also. This did not happen. When huge numbers were counted, it was found that, with strict regularity, 75 per cent. of the second filial generation were tall, but the remaining 25 per cent. were dwarfs, like their one dwarf grandparent The shortness had "skipped a generation."

Instead of taking percentages, let us take single numbers. We now have three tall plants and one short one to deal with. The first and simplest fact is that the short ones, when bred together, yield nothing but short offspring, generation after generation. Clearly there is no tallness in them, visible or invisible, patent or latent, though both their parents were tall. But of the remaining three plants, distinctions must be made One of them, like the one short plant, when tested genetically, is found to be a pure tall, like the original tall grandparent. Such plants mated with each other produce nothing but tall, generation after generation. The remaining two tall plants, however—that is to say, 50 per cent. of the second filial generation—behave, when bred from, exactly like their own parents—the tall plants of the first filial generation—again yielding offspring in the proportion of three tall to one short.

Dominant and Recessive Characters. These are the facts which Mendel ascertained; and what is true for tallness and shortness is true in exactly the same way for various other contrasted pairs of characters. Now, it is clear that, as the first filial generation shows us, the character tallness has the power of asserting itself over the character shortness, even though that be also present in some mysterious sense, as the results of further breeding prove.

Mendel, therefore, gave the name of *dominant* to characters which behave as tallness does; and the opposite character, which recedes in the presence of the dominant, Mendel called a *recessive*, though in our language, as Sir Francis Galton pointed out, the term *recedent* would be a more suitable alternative. If the dominant character is present, it asserts itself. Thus, in a short pea the dominant character is not present,

and, that being so, we shall not expect to find tallness appearing in any of the offspring of such peas when mated together.

But the case is more complicated with the tall peas. They may have nothing but tallness in them, and in that case all their offspring, and theirs, will be tall. But, as in the case of the first filial generation in the experiment above described, and in the case of half their offspring, along with a single dose, so to say, of tallness, there is also a dose of shortness. We require different names for those two kinds of tall peas, and the first are conveniently called pure dominants, and the second impure dominants. The results of breeding from the two kinds of dominants respectively will be as we have seen.

Segregation, the Basis of Mendel's Theory. Clearly we must form a new conception of all living individuals who are derived, as nearly all are, from two parents. Every such individual is in a true sense a double thing, as its history teaches us. Before we can understand it, or can predict the nature of its offspring, we must be acquainted with what comes to it from both its parents; and the central fact which Mendel discovered is that the respective parental contributions are not necessarily blended in the individual, but remain independent in this sense that they may be passed on separately into the germ cells produced in that individual.

This is the central fact of *segregation* upon which Mendelian theory is based. We may call the entities in the germ cells which give rise to characteristics in the individuals formed from them by the name of *factors*, and these Mendelian factors constitute the heart of our problem.

The Law Expressed by Symbols. It is convenient to use symbols to describe individuals, each of them, as we have seen, double, for Mendelian purposes. D will stand for dominant, and R for recessive. The symbol for a pure tall pea bred from a pure tall race will be DD—the factor for tallness was present in both the germ cells which combined to form that individual. The great fact which follows is that all the germ cells produced by such an individual in its turn will have the factor D in them. In this particular case they will all necessarily be tall. Generally speaking, brown eyes and blue are dominant and recessive in ourselves and behave accordingly, but Mendel knew nothing of that, which need only be mentioned now as a hint of what is forthcoming. The short pea, on the other hand, whatever its ancestry, must be one which has somehow got the factor R from both parents, and its symbol, of course, is RR. All the germ cells produced by such an individual necessarily carry the R factor also.

But now let us look at the constitution of the first filial generation bred from tall and short in Mendel's first experiment. From what has been said, we know that each of them must have in its constitution the D from one parent and the R from the other. In virtue of the D, they are tall, the dominant asserting itself; but because they have the R from the other side, they are impure dominants, the formula of which accordingly is DR or RD. Now, the capital fact about the impure dominant is that, unlike the recessive or the pure dominant, each of which produces germ cells of only one kind in the respect under discussion, the impure dominant, a double thing, made of different halves, produces two kinds of germ cells in equal numbers, half of them carrying the D factor and half of them carrying the R factor. There is no compromise —each germ cell is either of one kind or the other; and if we take sufficiently large numbers we find that the chances are even.

The reader can now write out for himself a genealogical table illustrating Mendel's law, as we have described it. Each individual must be described with two letters to indicate its double origin and nature. Then DD × RR yield all DR; DR × DR yield DD + DR + RD + RR, a result which, looked at casually, simply means three talls to one short. Each impure dominant parent, we see, is producing germ cells of the two kinds in equal numbers. They meet one another according to the ordinary laws of chance. Each D or R is equally likely to meet a D or an R. Hence the regular proportions which Mendel discovered are explained, and hence we understand why one dominant in three is a pure dominant, while the other two are impure.

How the Experiments Bear on the Study of Heredity. Mendel himself did not go at all into theory, but simply described the facts. He looked upon a dominant and recessive as contrasted factors, and offered no explanation either of their nature in themselves nor of the curious way in which they are opposed to each other, nor of the reason why there should be this relation between them, that, though they are both equal in other respects, one dominates over the other when both are present in one individual. We shall see later that an extremely simple and helpful explanation of the Mendelian facts has been supplied by the contemporary master of this subject, but the facts themselves are independent of any particular theory as to the nature of Mendelian factors.

The lessons which we immediately learn from Mendel's experiments are evident. In all studies of heredity we must attend to the nature of the individual mating—the particular parental combination. The statistical method, which, for instance, studies the records of the stud-book by breaking up the parental pairs, can never lead us to the truth, and in point of fact that method, thus applied, necessarily failed to note the simple fact that, when two chestnut horses are mated, all the offspring are always chestnuts.

Again, Mendel's experiments teach us that things are not always what they seem. Two individuals, apparently identical, may be profoundly different in respect of parental possibilities. No anatomical, microscopic, or chemical examination of the pure and impure dominant tall pea respectively will show any difference between them, or tell us which is which. Yet they are different, as breeding from them will prove.

C. W. SALEEBY

Places of Sale. Customs Regulations and Bonded Warehouses. Prohibited Goods. Imports for Re-export. Transhipment of Imports.

THE IMPORT TRADE

If the export trade of the United Kingdom is great, the import trade is still greater, for the total value of the goods that we buy as a nation is now about eight hundred million pounds a year. This enormous turnover—which, it must be explained, includes the cost of the goods themselves, the insurance, and the freight—must necessarily involve a vast amount of business; and it will be well if, at the outset, we understand with what parts of the world the import trade is done.

Divisions of the Import Trade. There are ten principal divisions into which the import trade of the United Kingdom may be divided. First of all there is the Continental trade, which includes the business done with most of the Continental countries. Next we have the Baltic trade, the very important business done with the countries bordering on the Baltic Sea. Then there is the North American trade, which includes the whole of the business done with the United States and Canada. Next we have the West Indian trade, including the business done with Jamaica and the other islands of the West Indian group. The South American trade embraces business done with the various countries of South America. The Central American trade is the trade done with Mexico and other parts of Central America. The Levant trade is the business done with Syria and Asia Minor, once more important relatively than it is now. The Eastern trade includes the business done with India, Burmah, Siam, China, and Japan, and the Far East generally. The South African trade is the business done with the countries of the South African Commonwealth. Finally, the Australasian trade includes the business done not only with Australia and New Zealand, but with other adjacent islands.

Goods on Consignment. Most of the goods imported into this country consist of foodstuffs and raw materials for use by our manufacturers, and the bulk of these imports are shipped here "on consignment," as it is called. This means that the foreign or Colonial shipper has sent the goods here to be sold on commission by a merchant who has previously arranged for their receipt and sale. Sometimes the consignor sees to the marine insurance, and at other times the merchant on this side does so, this, of course, being entirely a matter of convenience and arrangement. The routine and methods are really those of the export trade reversed. The foreign shipper draws on the consignee in this country for about 75 per cent. of the amount of the invoice, and sends him the bill of lading and other shipping documents. The goods are then sold, and the consignee forwards to the shipper abroad particulars, together with any balance that may be due to him as a result of the sale.

Places of Sale. There are, in this country, regular and recognised places where various kinds of imported merchandise are commonly sold. Wheat and other grains, for instance, are sold at the Corn Exchange in Mark Lane, London, and also at Hull. East Indian and Colonial produce—tea, sugar, coffee, drugs, spices, and so on—are sold at the Commercial Sale Rooms in Mincing Lane, London, and also at Liverpool. The principal selling place for cotton is the Cotton Exchange in Liverpool, that city being the most convenient port for the United States, from which so much of the cotton comes, and also an excellent distributing centre for the cotton-mills in Lancashire. Wools are sold at the Wool Exchange in London and at Liverpool. Other goods have other selling centres.

Imports Against Orders. In addition to the goods sent on consignment a great deal of import business is done "against orders." The English merchant receives orders from manufacturers in this country and he in turn orders from the foreign shipper, or perhaps even orders from the shipper without himself having actual orders in hand from the English manufacturers. He may anticipate a rise in the market or a coming scarcity of material, and may import with a view of having good stocks for the rise.

Preparing to Take Possession. To get possession of the goods that have been shipped from a foreign or Colonial port it is necessary that the British merchant shall have the bill of lading, which is the document entitling him to have the goods handed over. This, of course, is sent on by post, and as soon as he gets it the merchant will make inquiries as to when the ship bearing the goods will arrive. The owners or agents of the vessel will probably be able to tell him, or he can consult Lloyd's list or the shipping columns in the leading newspapers. As soon as the vessel has arrived the merchant must obtain from the agents of the shipping company a delivery order, and this he usually gets in exchange for the bill of lading. Some shipowners and agents, however, write the delivery order across the bill of lading itself. Before, however, the delivery order can be claimed, any outstanding charges owing to the shipowners must be paid, for, according to commercial law as it now stands, the owners of a vessel can stop delivery of the goods they have carried until their charges are fully met. Sometimes the exact amount of the freight cannot be known at once, although the merchant requires immediate delivery of the goods. In such a case it is usual for the merchant to pay a sum

which it is anticipated will cover the freight, and then, later on, when the exact charges have been worked out, there is an adjustment.

Custom House Regulations. Before delivery can be obtained there are a number of Customs regulations that have to be carefully observed. Although this is a free trade country, there are still a number of articles upon which an import duty is levied. These articles are cocoa, coffee, chicory, dried fruits, tea, sugar, molasses, glucose, saccharin, wines, beers, spirits, tobacco, transparent soap in the making of which spirit has been used, chloroform, chloral hydrate, collodion, ether, ethyl, confectionery in the making of which spirit has been used, playing-cards, and various other goods of which the substances mentioned form a part. The duties in this country on all these things are specific; that is, a charge of so much per pound or per gallon, or per other fixed quantity, is made. In many countries where there is an import tariff the duty is what is known as *ad valorem*; that is, it is not a fixed charge, but is made upon the value for the time being of the goods.

The Ship's Report. Within twenty-four hours of the ship's arrival a "ship's report" has to be handed to the Customs authorities by the captain or by some other officer of the ship properly authorised in writing by the captain to undertake the task; and until this is done no goods at all may be landed from the vessel. This document gives the name and tonnage of the ship, its character—whether it is a steamer or a sailing vessel—its port of registry, the number of the crew, with details as to how many are British and how many foreign seamen, the name of the master, and whether he is a British subject, and the port or place at which it has arrived. Then there must be full particulars of the cargo, with a description of the packages, their marks and numbers, the name of the consignee, and the name or names of the places where the vessel was laden. If any wreck has been passed on the voyage, particulars must be set forth in the ship's report. Then there must be a full description of the stores remaining on board, with the quantity of each dutiable article, such as wine, cigars, tobacco, etc., the number of alien passengers, if any, the pilot's name, the name of the station at which the vessel is lying, and the agent's name and address. It ends up with a declaration, duly signed by the captain in the presence of the Customs collector, which reads as follows: "I declare that the above is a just report of my ship and of her lading, and that the particulars therein inserted are true to the best of my knowledge, and that I have not broken bulk or delivered any goods out of my said ship since her departure from so-and-so, the last foreign place of loading."

The ship's report has to be made out in duplicate, the original being kept by the Custom House, and the duplicate sent on to the Customs officer at the place where the ship is to unload her cargo. Should there be any mistake in the ship's report, and any goods not have been entered upon it, the owners of these goods will not be allowed by the authorities to remove them from the vessel until the report has been properly amended by the captain of the ship.

Landing the Cargo. As soon as possible after this formality has been complied with, the cargo is landed, it not being the custom to keep it on board until the consignee claims it. The dock company or wharfinger takes charge of the goods, weighing and measuring them, and preparing landing accounts, weight accounts, and other documents which will be of use to the importer in selling them. Any damage that is discovered is entered at the end of the landing account, and the surveying officer then examines the damaged goods, and makes out a certificate of survey, which bears the name of the ship and her master, the invoice mark and number of the damaged package, and the cause of the damage. This certificate is used as evidence by the importer or the shipper when claiming from the insurance company. The Customs officials inspect the goods as they are landed, and if they are dutiable all the weighing, gauging, testing, sorting, and sampling, and the other operations are supervised by Customs officers. The figures are entered in their "landing books," which constitute the official record of the consignment.

Bonded Warehouses. If delivery is not taken at once, the dutiable goods are removed for storage to a bonded warehouse. These warehouses, which are owned by private individuals or companies, are built to fulfil certain Government regulations, and they are under the joint control of their owners and the Customs authorities. They are called bonded warehouses because their proprietors have entered into a bond by which they undertake to see that they are conducted properly, and that nothing shall pass out on which the duty has not been paid. The goods stored in these warehouses are said to be bonded goods, or goods in bond, and they can only be removed upon the duty being paid. For convenience the various floors and compartments of the warehouses are numbered, and the number of each is painted on the door, so as to be easily identified. Separate floors or compartments are allotted to different kinds of merchandise, one being for tea, another for tobacco, another for wines, and so on. Even the lightermen and carmen who handle dutiable goods have to enter into a bond with the Customs authorities, and only those who are thus bonded and licensed by the Commissioners of Customs are allowed to work in connection with bonded warehouses and goods. In fact, all those who have anything to do with dutiable goods are bonded; that is, they enter into a bond with heavy penalties as a guarantee that they will do everything in strict accordance with the Customs regulations.

Free Entry. The ship having been properly reported, the merchant makes his Customs "entry," in order to obtain delivery, and the method varies according to whether the goods are dutiable or free; whether they are for sale in this country or for re-export; whether they come in at a port of entry or at another place. The document necessary for the release of free goods is called a free entry, and it bears full particulars of the marks, numbers, quantities,

descriptions, and values of the goods landed, so that the Customs officials may quickly identify them. The various kinds of goods are not given their commercial or popular names in the entry, but have to be described according to their title or class in the official published import list. Two copies of these documents have to be made out, one, which is called the warrant, having the number of the packages in words, and the other, called the bill, giving the number in figures. The bill goes to the Statistical Department of the Board of Trade, and is used in the compilation of the records of the imports and exports of the United Kingdom. The warrant, after being signed by the Customs collector, is sent to the examining officer on the ship, or at the place where the goods have been landed, and becomes his warrant for the handing over of the goods set forth on the paper. With the warrant the landing order must also be presented if the goods are still on board at London or some other large port. This is addressed to the officer of the ship, and is his authority to deliver the goods. It must be signed and stamped by the Customs officer.

Clearing Dutiable Goods. To clear dutiable goods is a rather more complicated business. In this case, what is known as a warehouse entry has to be obtained, the name of the document being due to the fact that the goods are to be warehoused in a bonded store or warehouse. The entry is sent by the Customs official to the examining officer, and is his authorisation for the landing and warehousing of the goods. Sometimes dutiable goods are required for use directly they come from the ship. In such a case a form known as an "Entry for Home Use" must be filled up. This entry, however, cannot be made use of until all the import duties have been duly paid. Once the goods are in the bonded warehouse, then the warrant for home consumption is required before they can be obtained by the merchant. When the goods are in the warehouse the dock company give what is known as a dock warrant to the merchant. This is a negotiable document, and has to be properly endorsed. It sets forth that the goods specified on it are deliverable to the owner of the warrant; and when it has once been issued the dock company will only hand over the goods in exchange for the warrant. The document can be deposited against a loan, or sold, the goods it represents thus being sold or transferred with it.

Bill of Sight. It sometimes happens that a merchant cannot state with accuracy the quantity or other details of the merchandise that has arrived on the ship. In such a case, a document called a bill of sight is filled up. This sets forth the port at which the ship is lying, the importer's name, the wharf, or dock, or station, the ship's name, whether it is British or foreign, and, if foreign, the country to which it belongs, the master's name, and the port or place from which the ship has come. Then the marks and numbers are stated, and the number of packages, with the best description of the contents that the importer is able to give. At the foot comes a declaration: "I, so-and-so, importer of the goods above mentioned, do hereby declare that I have not received sufficient invoice, bill of lading, or other advice from which the quality, quantity, or value of the goods above mentioned can be ascertained." This is signed by the importer and the Customs collector. The bill of sight is then the warrant for the provisional landing of the goods, and the importer is allowed to examine them in the presence of the Customs officials. Not later than three days after landing, the importer must make a perfect entry by writing upon the bill of sight all the particulars that are not already inscribed there. This has to be done even if the goods are found to be free, and not only when they are actually dutiable.

Removing Goods from one Bonded Warehouse to Another. Sometimes it is desired to move dutiable goods from one bonded warehouse, where they are deposited, to another in some other part of the city, without paying the duty. In such a case a request note and permit or certificate is made out. The importer fills up part of this, setting forth in detail the goods he desires to move, giving the marks and numbers of the cases or casks, the bonded warehouse from which he wishes to take the goods, and that in which they are to be deposited. He must also state the means of removal, as, for instance, if it is by steamer. A warrant form is also filled up by the merchant, giving full particulars, with the name of the licensed carman whom it is proposed shall move the goods. On this warrant occur the words: "This is to certify that bond has been given for the due arrival and warehousing as above within" so many days, and the name and occupation of a proposed surety is added. The whole is then signed by the collector or clerk of the bonds, and it is sent with the request note to the Customs officer at the bonded warehouse where the goods are lying. He signs the bottom of the request note, which states that "The proper duties having been paid or secured by bond, the above-named goods may be delivered." He also signs an order to the warehouse keeper, on the back of the warrant, telling him to deliver the undermentioned goods for removal to the new bonded warehouse. The goods are then removed by the carman and transferred to their new destination

Imports for Re-export. Of course, a great deal of the merchandise that comes into this country and is reckoned among our imports is re-exported to foreign countries and the various British Colonies, and at the present time the proportion thus re-exported is about 15 per cent of the total exports. When goods are stored in bonded warehouses, it is distinctly understood that they may be exported without paying duty, but this exportation is carried out under certain restrictions which are rigidly enforced. An exporter must hand to the Customs authorities a bond giving full particulars of the goods, and security for their shipment abroad. This bond has to be signed by the exporter or his authorised representative, and by another person of standing, who acts as surety. The two together bind themselves in a penalty of twice the amount of the duty that the goods shall be re-exported.

The bond has to be executed in the presence of the Customs official, and must be stamped, the stamp varying according to the amount of the penalty. The bond, together with a bond note setting forth particulars of the proposed exportation—the name of the exporting merchant, the ship's name, the port it is in and the port it is going to—are handed to the Customs bond clerk, who examines and signs the note and returns it. On the back of the bond note are two forms, one giving full particulars of the goods to be exported, with quantities, import marks and numbers, and export marks and numbers, the second form being an order to the warehouse-keeper to deliver the goods.

These are handed to an official in the warehouse department of the Custom House, who examines them and, after signing the warehousing order, returns it to the merchant. The ship note is then made out, which is really a notice to the Customs officer on board the vessel which is to take the goods, advising him that they are being sent for shipment. If the goods are being sent by van, the carman's name in addition is written on the note.

The whole of the documents are then handed to the licensed carman, and he delivers them to the proper officials, receiving the goods in exchange, and on delivering them on board the vessel that is to take them abroad he receives a mate's receipt, which he hands over to the exporter. Bills of lading, invoices, and other documents are then made out as in the case of ordinary exports.

Transhipment of Goods. Much of the re-exportation is carried out by what is called transhipment of goods; that is, by transferring the cargo from one ship to another. Such transhipment can take place only at certain ports specified by the Customs authorities. There are thirteen of them in all and they are London, Liverpool, Southampton, Swansea, Hull, Hartlepool, Grimsby, Goole, Newcastle-on-Tyne, Newhaven, Poole, Glasgow, and Leith. Goods imported for transhipment are regarded as goods entered for exportation. They must be described in the ship's report by their proper and specific name, and not merely under some general heading. Further, they must be described in the report as "in transit."

Documents Needed for Transhipment. Transhipment need not necessarily be direct from one ship into another or by barge or lighter. It may take place by land as well as by water; and if it be by land, only a licensed carman may do the work, just as, when it is by barge or lighter, only a licensed lighterman can be engaged. For transhipment a bond similar to that already described has to be entered into, and a bond note has to be made out, but before applying for these the importer must present to the clerk who has charge of the ship's report a transhipment bond warrant, which contains a full and detailed description of the goods. The clerk compares this with the ship's report, and if they agree he writes on the warrant the word "Correct," signing it with his initials. A transhipment delivery order is then made out "To the officer of Customs on board the [here comes the name of the ship, and her captain]. Send up in charge of an officer of Customs, to be delivered into the custody of the proper officers at [such and such a dock] for transhipment only on board the [name of the ship] for [name of the port to which the goods are going]." Then follow the details and marks of the cases of goods. A transhipment lighter note or a transhipment cart note, according to whether the things are being transferred by water or by land, and a shipping bill, are also made out. On receiving the transhipment delivery order, the Customs officer who is in charge of the importing vessel allows the goods to be handed over to the licensed lighterman or carman for conveyance to the exporting vessel. A transhipment lighter or cart note is given with the goods, and this, with the shipping bill, is given to the officer on board the exporting vessel when the goods are delivered. He certifies to the shipment of the goods and, if requested, also gives a mate's receipt.

Using the Railway in Transhipment. When goods imported "in transit" are removed by railway from one transhipment port to another, the railway company which conveys the goods must enter into a bond that they will deliver them into the care of a properly authorised Customs officer at the port of exportation. Sometimes a Customs officer is sent in charge, in which case a return railway ticket or pass, together with an insurance ticket for five hundred pounds, must be provided, and a deposit made to cover the expenses incurred. There must be no undue delay in the delivery of the goods from the importing vessel to the railway vans, and they must be delivered into the charge of the Customs officials at the port of shipment within forty-eight hours from the time they were taken from the import vessel. The railway vans conveying the goods are placed under Crown locks, and if an officer does not accompany them they are also officially sealed. Of course, all the opening and re-fastening of packages for Customs examination have to be done by the owners or agents, and at their own expense. This applies to goods that are examined on importation, transhipment, or exportation.

Accuracy Necessary in Filling Up Forms. It is important that the clerks whose duty it is to fill up the various forms for the Customs authorities should do so with the utmost accuracy, as any errors, such as giving wrong quantities or values, entering up dutiable goods on free entry forms, and so on, are very serious. The Customs officers are extremely expert in detecting errors of this kind, and when they suspect anything is wrong they have the power to call for documentary evidence showing the correctness of the entries. Frequent or serious inaccuracies are punished by fines; and although occasional mistakes may be unavoidable, it must be remembered that the fact of an error being made unconsciously and by accident is not sufficient to bring about an escape from the fine.

The Need for Experience. Of course, the Customs authorities take into consideration

the frequency with which such mistakes occur in the documents of a firm, but the seriousness of a mistake can easily be understood. Some firms, in fact, make their clerks pay any fines that may be incurred through their own carelessness. Of course, while a new-comer to the shipping trade may make errors through sheer ignorance and lack of experience, it follows that with experience liability to blunder decreases.

Errors, for example, are particularly liable to occur through the non-declaration of articles containing some of the materials that have to pay duty. As an illustration, while any shipping clerk would know that ethylic acid must be declared, even an expert may overlook the fact that this product is contained in liquid extract of bark, in many American patent medicines, in some calf's-foot jellies, in certain vinegars, in some fish glues, in hair-washes, in liquid preparations of meat, in oil of mustard, and even in certain toys, like the well-known bottle-imps. These are only some of the 150 or more articles, half of them being patent medicines and cures, that have been found on examination to contain ethylic acid, and therefore to be liable for duty. The same thing applies to other dutiable articles; and it is therefore essential that the shipping clerk should be a man of knowledge and experience. It is always wise, where there is any doubt as to the contents of the goods imported, to take out a bill of sight.

Importing Bullion and Diamonds. Bullion, coin, and diamonds have to be entered on a special form within 72 hours of arrival in an English port, the penalty for a failure to do this being a fine of twenty pounds. They may be cleared by handing a printed request to the examining officer, in which are given the marks and number of packages, and the weight, value, and description of the consignment. Of course, the bill of lading must also be produced.

Imports Prohibited though not Dutiable. In addition to dutiable articles, a number of other things are either prohibited altogether or only allowed to come into the country under certain restrictions, and the Customs authorities always keep a strict look-out for these — such things, for instance, as foreign prison-made goods, imitation coins, fictitious postage-stamps, foreign goods bearing British trade-marks, and so on. The Merchandise Marks Act of 1887 declares that all foreign-made goods which bear any marks suggesting British origin must have upon them some qualifying declaration, such as "Made in Germany." Not only so, but goods which bear a false trade description, as, for instance, port wine made in Germany, must have a qualifying mark or clause upon them before they can be allowed in.

Protecting the British Manufacturer. In order that the British manufacturer may not suffer by having foreign goods come into the country bearing his mark without authority, or with even a colourable imitation of it, the Board of Customs allow the manufacturers and traders of the United Kingdom to register their names or marks at certain ports, and this assists the Customs authorities in stopping illicit trade of the kind described. Of course, English manufacturers are not allowed to use even their own trade-mark on foreign-made goods imported by them, unless there is a qualifying clause "Made in Germany," or wherever it may be. As soon as any goods are detained on account of wrongly used names or marks that have been registered, the Customs authorities send notice to the owner of the mark, and any detention for more than forty-eight hours, apart from other illegalities in the import, is at his risk. For a longer detention than forty-eight hours, the Customs officials require security, as will be explained later.

Not only do the Customs officers detain goods on their own account because of forged trade-marks, but firms which have registered their names and marks may sometimes have information from abroad of a large consignment of goods being shipped from a foreign port, and about to arrive in this country. In such cases they may give information to the Customs authorities, but in doing so, and asking for detention, they take considerable risk, and have to give security, in case the Customs officials are sued for the detention. So important is this matter that it will be well to give in some detail the regulations concerning detentions on account of forgery of trade-marks and manufacturers' names.

Conditions of Detention. According to the regulations of the Commissioners, "Goods prohibited to be imported as hereinbefore recited, having applied to them forged trade-marks, false trade descriptions, or marks, names, or descriptions, otherwise illegal, which upon examination are detected by the officers of Customs, are to be detained by them without the requirement of previous information.

"In giving information with a view to detention, an informant must fulfil the following conditions, namely:

"(*a*) He must give to the collector or superintendent, or the chief officer of Customs of the port, or sub-port, of expected importation, notice in writing, stating the number of packages expected so far as he is able to state the same; the description of the goods by marks or other particulars, sufficient for their identification; the name or other sufficient indication of the importing ship; the manner in which the goods infringe the Act; and the expected day of the arrival of the ship.

"(*b*) He must deposit with the collector or other officer, as aforesaid, a sum sufficient, in the opinion of that officer, to cover any additional expense which may be incurred in the examination required by reason of his notice.

Security Required by the Customs Authorities. "If, upon arrival and examination of the goods, the officer of Customs is satisfied that there is no ground for their detention, they will be delivered. If he is not so satisfied, he will decide either to detain the goods, as in a case of detention upon an ordinary examination, or to require security from the informant for reimbursing the Commissioners or their officers all expenses and damages incurred in respect of the detention made on his information, and of any proceedings consequent thereon.

"The security thus required must be an immediate *ad valorem* deposit of £10 per cent. on the value of the goods, as fixed by the officer from the quantities or value shown by the entry, and also subsequently about to be completed within four days in double the value of the goods with two approved sureties. The *ad valorem* deposit will be returned upon completion of the bond, and will not be required if, as an alternative where time permits, the informant prefers to give a like bond before examination upon estimated value of the goods declared to by him under statutory declaration. If the security is not duly given as above required, there will be no further detention of the goods. In the above regulations the words 'officer of Customs' mean an officer acting under general or special direction of the Commissioners, and the words 'value of the goods' mean value irrespective of duty.

"The security taken under these regulations will be given up at the times following; that is to say, where given before examination, and if no detention, forthwith. Where given on detention, if the forfeiture is completed, either by lapse of time or ultimate condemnation by a Court of Justice, then on such completion of forfeiture; if the forfeiture is not completed, then if the goods are released by the Commissioners, and no action or suit has been begun against them or any of their officers in respect of their detention, then at the expiration of three months from the time of detention; or if the goods are released for failure of proceedings taken for the forfeit and condemnation thereof upon information under Section 207 of 'The Customs Consolidation Act, 1876,' and no action or suit has been begun against the Commissioners, or any of their officers, in respect of the detention, then at the expiration of three months from the trial of such information. If, within such periods as aforesaid, any such action or suit as aforesaid has been begun, then upon the ultimate conclusion of such action or suit, and the fulfilment of the purpose for which the security was given.

"These regulations apply to transhipment and transit goods, as well as to goods landed to be warehoused, or for home consumption."

Clearance Inwards and Outwards. There are many technical terms used in connection with the import and export trade which every shipping clerk should know, and he should also be absolutely clear upon the meaning of the terms. Clearance inwards and clearance outwards are examples As soon as a vessel bringing imports to this country has discharged her cargo, a Customs official known as a waterguard officer goes through or rummages the vessel; that is, examines it very carefully in every part, and checks whatever stores there may be aboard. If all the regulations have been properly complied with, he issues the ship's clearing note and stores certificate. A copy of the clearing note is then sent by the Customs officer to the office of the "principal searcher." All this is the clearance inwards of the vessel and means, in short, that the ship has been thoroughly examined by authorised officials who declare that all the requirements of the Commissioners of Customs have been complied with. Clearance outwards is a similar declaration for an outgoing ship. The various documents—the report inward of goods reported for exportation, the victualling bills, the master's declaration, and so on—are sealed to a label giving the names of the ship and her master, and the date of clearance. The collector seals the label if all is in order, and the papers thus sealed and signed constitute the vessel's authority to depart. Until all dock and harbour dues are paid, and proper life-saving appliances are on board, no vessel is granted its clearance outwards.

Sometimes a ship that has cleared at one port will visit another British port to take in further goods. In such a case the master of the vessel must deliver to the collector or other authorised official there an additional "Content" or declaration respecting the goods shipped at that port. This is attached to the label with the other documents, and sealed in exactly the same way. If several ports are visited, the same routine is followed in each case.

The Official Customs Forms. All the forms referred to in this article are printed by the official printers to the Government, and can be bought from duly appointed agents, who are usually stationers in the neighbourhood of the Custom House. Some of the forms, however, may be printed by private firms for their own use, provided that in all essential points they are in conformity with the official style. Only the largest firms would find it worth while, however, to print their own forms.

London and Other Ports. In conclusion, it must be mentioned that the methods of clearing goods and the Customs procedure vary slightly at different ports, and the methods described above are those in vogue in the Port of London, which still remains far and away the most important port commercially in the United Kingdom. In addition to its many large docks—the East and West India Docks, the Royal Victoria Docks, the Royal Albert Docks, the Tilbury Docks (just outside London, but, of course, actually a London dock), the London Docks, the St. Katharine's Docks, and the Surrey Commercial Docks—it has a few smaller docks like the Regent's Canal Docks, and more than three hundred wharves, which line the river on both sides. The Customs authorities are quite alive to the competition of large foreign ports like Antwerp, Hamburg, Rotterdam, and others, and they are always ready to meet any real difficulties of the English importers by relaxing, as far as possible, hard and fast rules and forms and regulations, provided it is quite clear that there is no attempt to evade the claims of the Crown. No doubt the facilities for importers at the Port of London will be greatly increased now that the docks are no longer owned privately but are under Government direction, the Port of London Authority having charge of the river and its navigation between Teddington and the great docks already referred to above.

CHARLES RAY

Interference. Lessons from Soap Bubbles. The Spectrum and the Spectroscope. How the Spectroscope Discloses the Chemistry of the Stars.

THE WAVE LENGTHS OF LIGHT

We are now to turn to facts and phenomena which depend for their production and for their comprehension upon the wave theory of light, and which have led to developments of knowledge that can be described only as amazing. Let us recall, in a few brief phrases, what has already been asserted as to the wave theory. We have seen that the history of the wave theory of light really begins with the discovery of what is called interference, and already we know what that term means, because we have studied it, in some measure, under *sound*.

Waves of Sound and Waves of Light. Now, interference is a common property of all forms of wave motion, and it is worth considering in the abstract before we discuss the actual interference phenomena of light. It does not matter whether, for instance, the waves are to-and-fro waves in air or whether they are transverse waves in the ether. The difference between the wave motion constituting sound and that constituting light is measureless in many respects. But they are both wave motions, and therefore they both exhibit interference, and precisely analogous consequences of such interference. As we have seen, if the waves under discussion be water-waves caused by throwing stones into a pond, the result of interference will be to make the elevations of the waves higher when the crests of the two waves happen to coincide, and to make the troughs deeper when two troughs coincide.

Precisely analogous is interference in sound-waves; an exactly parallel thing happens. We interpret the superposition of crests and troughs as increase of loudness, and the mutual neutralisation of waves—caused as we shall now see—we interpret as silence. Similarly, as has previously been said, Young discovered that there are conditions in which the addition of light to light will cause darkness, and its removal will leave light.

Two Light-waves May Make Darkness. The general proposition of interference, as stated by Professor Tait, is this: " When two similar and equal series of waves arrive at a common point they interfere . . . with one another so that the actual disturbance of the medium at any instance is the result of the disturbances which it would have suffered at that instant from the two series separately." He goes on to say: " Thus, if crests, and therefore troughs, arrive simultaneously from the two series, the result is a double amount of disturbance. If, on the contrary, a crest of the first series arrives along with the trough of the second, the next trough of the first series will arrive along with the next crest of the second—and so on. One series is then said to be half a wave length behind the other. In this case the portion of the medium considered will remain *undisturbed.*" In the case of water-waves, these facts are illustrated by the tides at the port of Batsha, the peculiarities of which were discussed by Newton himself. At this place " the ocean tide-wave arrives by two different channels, one part being nearly six hours, or half a wave length, behind the other. As a result, there is scarcely any noticeable tide at Batsha itself, though at places not very far from it the rise and fall are considerable."

Precisely the same is true of sound-waves. Says Tait: "Two sounds of the same wave-length and of equal intensity produce a silence if they reach the external ear with an interval of half a wave-length, or any odd multiple of half a wave length " The interesting circumstance is that these facts were known before the wave theory of light was accepted and before the interference of light was demonstrated.

Allusion has already been made [page 1796] to Lord Brougham's violent attack upon Young in the " Edinburgh Review." Let us now quote a few sentences from Young's dignified reply. It is to be noted that it was an "argument from analogy " that led Young to the truth, and that is why we have insisted at such length upon the parallelism between the phenomena in interference, no matter whether they are displayed in water, air, or ether.

Young's Explanation of Interference. Having stated that his discovery was due to reflection upon the " beautiful experiments of Newton," and having declared that his law seemed to account for more phenomena than any other law of optics then known, Young goes on to say: " I shall endeavour to explain this law by a comparison. Suppose a number of equal waves of water to move upon the surface of a stagnant lake with a certain constant velocity, and to enter a channel leading out of the lake. Suppose, then, another similar cause to have excited another equal series of waves, which arrive at the same channel with the same velocity, and at the same time with the first." He then goes on to show that in such a case the waves must either reinforce one another, or, if there be an interval of half a wave length, "the surface of the water must remain smooth; at least, I can discover no alternative either from theory or from experiment. Now, I maintain that similar effects take place whenever two portions of light are thus mixed, and this I call the general law of the interference of light."

We must next proceed to the study of the simplest and, in a sense, the oldest of interference phenomena—those which were studied exhaustively as far back as the time of Newton.

We shall find that facts of the utmost interest and value are to be derived from the study of objects which most of us may never have considered worthy of serious study—namely, soap bubbles.

Everyone is familiar with the fine colours produced in a film of soap blown into the form of a bubble. To the eye of the physicist soap bubbles are of the utmost interest; nor is the interest confined to the colours which they show. Plainly, the soap bubble illustrates the action of molecular forces which hold the particles of the film together. Just a century and a half ago it was shown that a soap bubble tends to contract, so that, if we relax the pressure at the end of the tube, the bubble will become smaller. The force so exercised is that force of surface tension which has already been described as a general property of the surfaces of liquids. [See page 996.]

Light and Soap Bubbles. Here, however, we cannot return to this aspect of the questions suggested by soap pubbles. For our present purpose we have merely to note the fact that the bubble is a spherical film which has an appreciable, though small, thickness. The film has two surfaces, an inner and an outer, both of which are exposed to air. The important matter for our present purpose is to consider the behaviour of light in relation to this film and its surfaces.

The soap is not the important thing, for we do not see such colours in an ordinary solution of soap. The essential thing is that the soap is spread out in the form of a film. Indeed, the same phenomena are shown by other films. Many liquids poured upon water will spread themselves out into a thin film that shows these colours. They are also shown by plates of various transparent substances if these are capable of being made thin enough. In other words, the soap bubble merely provides us with a familiar and beautiful illustration of what we may call, in general, the colours of thin plates.

Before leaving them let us note one striking phenomenon exhibited by soap bubbles and explained by Young's principles. This can be shown either by a soap bubble or, as is more convenient for many purposes, by a film of soap spread out within a small ring or frame made for the purpose. These soap films are very largely used for experiment and illustration. If we take a soap bubble or a soap film held vertically and protected from currents of air, and watch it, we find remarkable consequences as it proceeds to drain, thus causing its uppermost part to become very thin. We find that this thinnest part becomes black; if it can be seen at all it is only by light reflected from particles of dust on its surface. This fact can be perfectly explained in terms of interference.

Newton's Coloured Rings. The appearance which goes by the name of Newton's rings must often have been observed by any reader who has done work with the microscope. If we take two perfectly clean cover-glasses—very thin pieces of glass used in microscopy for covering the object to be examined—and press them firmly together, a series of coloured rings will be seen to spread from the point where the pressure is greatest, and to widen out as the pressure is increased. These rings of colour are due, we must conclude, to the passage of light through the very thin film of air enclosed between the two cover-glasses.

Following various physicists, Newton set to work to ascertain the precise relation between these rings now known by his name and the thickness of the film of air that produces them. His method was to place a flat piece of glass upon the convex face of a very slightly curved plano-convex lens. This arrangement gave him a film of air which regularly, but very slowly, increased in its thickness outwards from its centre. Under these conditions Newton obtained a series of coloured rings, all concentric, the centre being at the point of contact between the two pieces of glass. Obviously the next proceeding was to use light of one colour instead of compound white light. When Newton did this he found that the rings he obtained were alternately coloured and dark. The experiment is always a striking and beautiful one; usually a brilliant yellow light is employed, which yields a splendid series of black and yellow rings. But the size of the rings was not the same with all kinds of light. With light from the red end of the spectrum the rings had a large diameter, but as the various colours were gone through up to blue, the rings became smaller and smaller. This fact suffices to explain the appearance shown with white or compound light. The rainbow effect of the colours thus obtained is due to the sorting out of its constituents.

Explanation of Newton's Rings. In terms of the wave theory of light the facts can be satisfactorily explained. We have merely to conceive that some of the light is reflected at the upper surface of the film, and some at its lower surface. (In the case of the soap bubble, read *outer* and *inner* for *upper* and *lower.*) We have now merely to apply our general principles of interference. At the points where the film is of such a thickness that the two reflected streams of light differ in phase by a wave length exactly, or by a multiple of their wave length, they will reinforce one another, with the consequence that we shall see a bright ring. But, at other points, intermediately placed, the film must be of such a thickness that the two streams, reflected from the two surfaces, differ in phase by half a wave length, or by an odd number of half wave lengths. In such a case, we shall have a state of affairs precisely similar to that conceived by Young in the case of waves of water in a channel. Light added to light will cause darkness—this being the only known instance in which two whites make a black—and a dark ring will be produced.

Measuring Wave Lengths of Light. Not only do Newton's rings provide a striking instance of phenomena which can be explained on the wave theory of light alone, but they also contribute to the wave theory of light by providing us with a means of measuring wave lengths. To discuss this in full would require

more geometry than is desirable here. If, however, we consider the angle at which light may fall upon an air film of constant thickness, we shall see that interesting consequences must follow according to the angle of the incident light. The more oblique the incidence of the light, the less is the retardation of the ray which is reflected from the further surface of the film. It can be shown that a complete geometrical discussion of these facts gives us means for measuring the wave length of light.

But there are entirely different methods of producing interference, and these lead us to further complexities. When we were discussing the history of the theories of light we noted how the rectilinear propagation of light and the occurrence of sharp shadows seemed to turn the scale against the wave theory and in favour of the corpuscular theory.

Diffraction of White Light. We must now look into the question of shadows more closely, with reference not only to the wave theory of light, but also to the phenomena of interference. If we make light travel through an extremely small aperture—having some reasonable proportion to its extremely small wave length—we find that the light behaves as it should behave, if it be a wave motion. It suffers diffraction, or *breaking apart*, in all directions; its behaviour in such a case is entirely opposed, evidently, to the corpuscular theory.

The consequence of diffraction in the case of white light is to produce coloured fringes, and this may be done by many means. Thus, we may employ a narrow slit, such as has already been instanced. If we make such a slit in a piece of cardboard and place it in front of a candle, and then if we make another similar slit in another piece of cardboard, hold it up to the eye, and look through it at the light passing through the first slit, we shall see these fringes.

Diffraction Fringes. But any opaque body of sufficient narrowness placed in the way of a beam of light will similarly cause diffraction. For instance, we may employ a narrow wire, and place it in the path of light coming through a narrow slit, and so may obtain diffraction fringes. These have been produced by the action of the two edges of the wire upon the light; and we shall best understand the phenomenon if we consider it in its simplest form, namely, that of the casting of a shadow by the edge of any opaque body.

If we arrange an experiment, using light from a luminous point, we do not find, as we might expect, that the shadow has a sharp edge. On the contrary, there is a gradual transition from light to darkness, the light slightly invading the area which should be dark—and which would be dark if light were a stream of corpuscles; whereas, on the other hand, the area which should be uniformly light shows a series of fringes which gradually fade away. The appearance seen upon the screen, therefore, is not a sharp transition from dark to light. Fresnel readily explained these fringes in terms of interference.

Diffraction Gratings. These facts are applied, in physical inquiry, in the employment of what are called *interference* or *diffraction gratings*. A grating may have various forms. It may consist simply of a series of fine wires, parallel and equidistant, or a piece of glass on which such lines have been ruled. Such diffraction gratings are now almost invariably employed in the spectroscope in place of the prism. Sometimes it is desirable to employ other transparent materials instead of glass. If glass be used, the lines have to be ruled by a diamond, but a very large number of lines are necessary, and so the diamond is soon worn down. About fifteen or twenty thousand lines to the inch are needed, though it is possible to have as many as fifty thousand. In order to economise in diamonds, a modern diffraction grating is not a transparent grating at all, but a reflecting one, and is made of very finely ground and polished speculum metal, which a diamond can rule without wearing away nearly so soon as when glass is employed.

When we look at light from a narrow slit through a diffraction grating we see an image of the slit in the middle, while on each side of it is a series of coloured images which are more and more spread out the farther they are from the centre.

The Octave of Light. Under these conditions it is possible, by means into which we cannot here enter, to measure the wave length of light of various colours. The approximate results may, however, be noted. The wave length of visible light shows, as we know, a range of slightly less than one octave—if we may borrow this convenient analogy from sound. The longest wave length that stimulates the retina, that of red light, is about one thirty-thousandth of an inch in length. The shortest appreciable wave length, that of violet, is approximately half as long; that is to say, one sixty-thousandth of an inch.

These figures appear at first to be incredibly small. Certainly they are small when compared with the wave lengths of audible sound, which have to be expressed in feet, but, on the other hand, one thirty-thousandth of an inch is not really so very small relatively to many distances which we are otherwise acquainted with. For instance, it is possible, as we have already seen, to make fifty thousand lines side by side within the space of an inch upon a piece of speculum metal. Again, this distance, when compared with the probable dimension of molecules—including even very large molecules—is actually very great indeed. In other words, we must remember that, in comparison with the size of the objects which we should like light to reveal, its wave length is hopelessly large.

The Spectroscope. We must now consider a new optical instrument, of very great interest in itself, and of supreme interest in consequence of the extraordinary insight which it has given us, and which it alone can give us, into many of the greatest facts of Nature. We already know, in general terms, what a

spectrum is, and the *spectroscope* is none other than a device for forming and examining the spectrum of any light that we may care to examine. The most natural and simple method of forming a spectrum would, of course, be by means of a prism, though the prism has been largely replaced, for this purpose, by means of a diffraction grating. The two means effect the same end, but by somewhat different principles, the prism causing dispersion of the various constituents of compound light because of the different speeds at which these constituents move through glass. The grating causes similar results because of the differences of wave length between light of various colours. If we ask ourselves, however, why different colours move at different speeds through glass, we shall see that the two methods depend upon the utilisation of one and the same ultimate fact of light.

The Lines of the Spectrum. When we examine the spectrum of sunlight, we find various dark lines upon it. These have long been known, and were first exhaustively studied by the physicist Fraunhofer. He made a careful list of them, and gave them names, employing the letters of the alphabet for this purpose. These dark lines of the spectrum of sunlight, and of light from various other sources, have revealed to us certain truths concerning the chemistry of the universe in general, and we must study their production with the very greatest care. We may begin by considering spectra that are much more simple than this of sunlight—which, as a matter of fact, is almost infinitely complex. Equipped with the spectroscope, we can examine the light given out by any luminous body, and we can make various bodies luminous for this purpose. We then make a remarkable discovery as to the fundamental distinction betwen two different kinds of spectra. When we have appreciated this distinction, we shall be on our way towards understanding the principles of *spectrum analysis,* and of realising the significance of the dark lines in the spectrum of sunlight.

The Two Kinds of Spectra. We find that spectra are of two kinds. In certain cases, the spectrum is a continuous band of colour. In other cases, it consists merely of a series of coloured lines, between which there are dark intervals. The spectra of the first kind we call *continuous,* and those of the second *discontinuous.* We further discover the very simple law that continuous spectra are produced by luminous solids, while discontinuous spectra are produced by luminous gases or vapours. This simple statement led to one of the most significant and remarkable astronomical discoveries of the nineteenth century. If we attempt to interpret the meaning of discontinuity or continuity of a spectrum, we see that a luminous solid must necessarily, as its spectrum is continuous, be giving out light of all wave lengths—within certain limits. These limits apply to a luminous gas or vapour also, but such a gas or vapour differs from the solid in that, within such limits, it gives out light only of certain particular wave lengths, and of none other. Hence the dark intervals between the bright lines of the discontinuous spectrum of a glowing vapour or gas. Some fifty years ago the late Sir William Huggins applied this fact of the two kinds of spectra to a great astronomical problem—the nature of the nebulæ. He demonstrated the truth of the contention, then supported by an amateur called Herbert Spencer, against all the astronomical authority of the time, that what appeared to be nebulæ or clouds of gas are *really* nebulæ, and are *not* merely star clusters, which are so remote that the telescope cannot resolve them into their constituent stars. Not only so; Huggins showed how the quality of the spectrum changes, becoming intermediate between the discontinuous and the continuous, as the nebula becomes resolved into planetary or solar masses. This is not, of course, to say that the process of celestial evolution was observed in any given case, but that various celestial bodies seemed to illustrate various stages in this evolution.

Seeing an Atom. Now, when we come to look more closely at the discontinuous spectra of gases, and find that they vary in different cases, we discover that in the spectroscope we have an optical instrument which can enable us to accomplish, in a sense, the feat of seeing atoms, which the microscope is impotent to perform. Similarly, also, where the telescope fails us, the spectroscope is not at a loss. Of these three instruments for seeing with, the spectroscope is indeed incalculably first in its power of insight.

Let us take some of the vapour of sodium and examine it by means of a spectroscope. It will suffice to put a morsel of salt in a spirit lamp and examine the characteristically yellow flame which is produced. Any sodium salt will act similarly. The spectrum produced has the most remarkable characters. There is darkness everywhere except for a pair of brilliant yellow lines placed very close together, and having the position corresponding to the yellow part of the spectrum of sunlight. We may take any number of other instances, and we always find that each of them has its own characteristic light. The differences between these various kinds of light must be referred to atomic differences, plainly. They do not depend upon the nature of any *compound* that we may employ for examination, but solely upon the nature of the *elements* in those compounds—solely, that is to say, upon the nature of the atoms in question.

Here we can merely note that the particular kind of light produced by a particular kind of atom—the particular wave length, that is to say, of the ethereal vibration caused by that atom—is determined by the movement and behaviour of the electrons composing the atom. The new corpuscular theory of matter takes up the facts of spectroscopy and builds them, with so many other facts, into an organised and rational whole.

Fraunhofer's Notable Discovery. Newton noticed the dark lines in the spectrum of sunlight, but he does not appear ever to have asked himself what they meant. It was left to Fraunhofer to discover their tremendous significance. He showed that certain of the lines—the dark ones—in the spectrum of sunlight

precisely correspond in position with certain bright lines which constitute the spectra of various elements. Thus, for instance, there is the most absolute correspondence between the double yellow line of sodium light and the double dark line or double gap in the yellow part of the spectrum of sunlight. Evidently coincidence could not explain these facts—they were too numerous.

How Spectrum Lines Correspond. When we were discussing sound we noticed how sounds of certain wave lengths could be picked up by vibrating bodies of suitable physical character. For instance, the A string of the piano will be thrown into sympathetic vibration if a tuning-fork of the same note be sounded loudly near it. This principle will enable us to understand the now accepted and thoroughly verified theory which explains the correspondence between the dark lines of the solar spectrum and the bright lines of the various gaseous spectra. When we make the experiment, we find that if the vapour of a given substance, such as sodium, be interposed in the path of light given off by another specimen of that same substance in a state of incandescence, or in the path of a continuous spectrum, the bright lines characteristic of the substance in question are precisely replaced by dark lines. Evidently the vapour is enabled to absorb the particular kind of light rays which correspond to its own composition, being, indeed, the very rays which it would itself give off were it made luminous. The only necessary condition for success in this experiment is that the radiant energy of the source of the original light must be greater than that of the body interposed between the original source and the eye.

The Chemistry of the Heavens. When we apply this principle to the results of celestial spectroscopy, we see at once that we are entitled to assert the existence of sodium in the sun. As the light from the main body of the sun passes outward, it has to make its way through outer layers, which are in the gaseous state, but are at a lower temperature than the deeper parts. We can interpret the dark lines corresponding to sodium in the solar spectrum only by supposing that there are atoms of sodium in the outer envelope of the sun which, by the principle of sympathetic vibration, are capable of picking out light of the wave length proper to themselves, and so leaving dark gaps in the spectrum of sunlight when it reaches us.

These results constitute one of the most significant and stupendous achievements of modern science, for the spectra of the stars, and of comets also, contain dark lines, and thus we are actually enabled to discover the chemistry of the heavens. The subject cannot be left here without the assertion of the stupendous fact that the sun and stars are made up of the same elements as are found in the very tissue of the human eye that perceives them.

The Boundaries of the Spectrum. When a wide compass of the ethereal vibration, compounded into that great chord of harmony, the visible part of which we call white light, is analysed by the spectroscope, or sorted out into its various kinds, it must necessarily be that many *notes* are to be found beyond either end of the visible part of the spectrum. The radiant heat mixed up with the sunlight, for instance, is put into its place by the spectrum, as also the rays which lie beyond its violet end.

Thus, the use of the spectroscope affords a splendid opportunity for studying many of the notes of the ethereal keyboard that lie beyond our range of immediate sensation. If, for instance, we use a screen painted with quinine sulphate instead of an ordinary white screen, and throw analysed sunlight upon it, we shall find that light is reflected from the screen at a point well beyond what was formerly the limit. Similarly, there are substances which, when placed not in the course of the visible light from the prism, but just beyond its violet end, become visible.

Fluorescence. The name applied to the remarkable character displayed by quinine and other substances is *fluorescence*. This word is somewhat loosely used in common speech, but it has a precise physical meaning. The only valid explanation of the behaviour of the quinine upon the screen in the experiment we have quoted is that it transforms the ultra-violet rays, which are too short to be visible by our eyes, into light of longer rays which we can see. Many bodies absorb violet rays and emit them as green or red rays.

It is noteworthy that fluorescence was first observed (by Sir David Brewster) in an alcoholic solution of *chlorophyll*, the familiar green colouring matter of plants. When sunlight passed into this, its course was marked by a red streak. Fluorescence is of extreme interest in relation to the new theory of matter, but we cannot here discuss it at any greater length. We may merely note the observation of Sir James Dewar: that many substances which exhibit no fluorescence at ordinary temperatures show this property in a very high degree when they are lowered to such temperatures as that of liquid air.

Light Without Heat. Concerning the violet and ultra-violet rays, we must here note further merely that they are practically without any heating action, thus contrasting markedly with the rays at the lower end of the visible spectrum. As regards chemical action, however, the converse is true, that of the ultra-red and the yellow rays being negligible, while the violet rays, as every photographer knows, are extremely potent in this respect—as also are the ultra-violet rays.

There are dark lines—if such a term be applicable—in the spectrum of ultra-violet light, as photography has proved.

Comparatively recently it has been shown that these rays, besides having a great value in astronomical research, enabling us by the camera to see stars which we could not otherwise see, are of very great interest and of very great therapeutic value in relation to certain conditions of the skin of man and lower animals —or, rather, we should say, in relation to living tissues in general.

C. W. SALEEBY

Details of the Dry and Wet Processes. The Machinery and Plant Used. Cement Compositions. Analysis and Tests.

PROCESSES IN CEMENT-MAKING

Dry Process. In describing this process we think it best to take the case of a typical instalment just as if we were going over cement works using the process, and describing the plant [**18, 19**, and **20**] we should find there.

In the typical process we have chosen the plant illustrated treats limestone of average hardness, and clay shale. The output is 60,000 tons of Portland cement per annum, so that assuming that the kilns work 300 days per annum, we get an average output of 50 tons for each kiln per day.

The raw materials are brought to the works in tip waggons on rails (1), and are weighed outside to control the proportion of the ingredients. The raw materials are tipped into the three crushers (2) and (2b), the first of which is used for shale, and the two others for limestone. These crushers are arranged between the four dryers (4), and connected with them by means of the elevators (3), so that each of the crushers can be connected with either of the two drying drums which lie one on each side of it. This precaution is taken in case one of the dryers should be put out of action for repairs.

The materials are kept separate as they pass through the dryers, and are thence distributed into the three elevators (5), each of which again can be connected with either of the two dryers. The dried raw materials are thus elevated and thrown into hoppers (6), whence they are loaded into tip waggons running on the two lines of rails across to the raw mill house, and shown in section [**20**.] Workmen push the waggons along the line, and at the same time look after the proper distribution of the raw materials.

Preliminary Coarse Crushing. The raw mill consists of three kominors or modified ball mills, each of which holds 2½ tons of steel balls. These kominors are marked 8, and the hoppers into which the raw but dried materials are fed are marked 7, on the drawing.

Two of these placed together are for limestone, and the third grinds shale. Each material is ground separately.

After being roughly ground in the kominors the raw materials are brought by the conveyers (9) and the elevators (10 and 11) to the mixing bins or silos (2 and 12b), the first of these taking the shale only, and the two others the limestone. At the bottom of these, extracting worms (13) are arranged, which draw out a considerably larger quantity than that required to keep pace with the supply to the kiln. This excess of material is returned to the elevators (10 and 11) and mixed with the fresh stuff coming from the mills, thus helping to keep the supply of uniform composition.

Weighing and Mixing. The elevators convey the coarsely-ground rock to the automatic weighing machines. There are two separate machines, each of which is regulated so as to weigh the exact proportion of the raw material, one for the shale, and the other for the limestone. They are coupled together, so that they may automatically discharge when both are filled with the right weight of material. The surplus brought up by the elevators (10 and 11) and not required by the weighing machines is returned to the bins, and in this way a large quantity is constantly circulating through them, so that as the material is drawn off for use it represents a very fair average of the whole.

The weighed and mixed raw materials from the automatic weighing machines are discharged into the worm (16) and thence distributed to the two tube mills (18) through their feed hoppers (17). These are full-sized machines, each taking about ten tons of flint pebbles. Here the mixture of raw materials is not only finely ground but very intimately mixed.

Mixing Machinery. After leaving the tube mills the finished fine raw meal is taken by the elevator (19) and the conveyer (20) to the three mixing bins (22). A distributing worm, not shown in the drawing, runs above them. The three bins are provided with six extracting worms (23) which discharge into the collecting worm (24) on the ground level. This, again, discharges into the raw meal elevator (25), from which the raw material is distributed by means of a distributing worm (26) to the feeds (27) of the four rotary kilns.

The extracting worms, collecting worms, and elevators, however, are constantly circulating a considerable quantity of raw meal over and above that required for the immediate use of the kilns, and this surplus is returned to the bins through another distributing worm (28). This, again, is a necessary precaution, in order to ensure thorough mixing of the raw meal, and to obviate any variations which may occur from time to time in the composition of the raw materials.

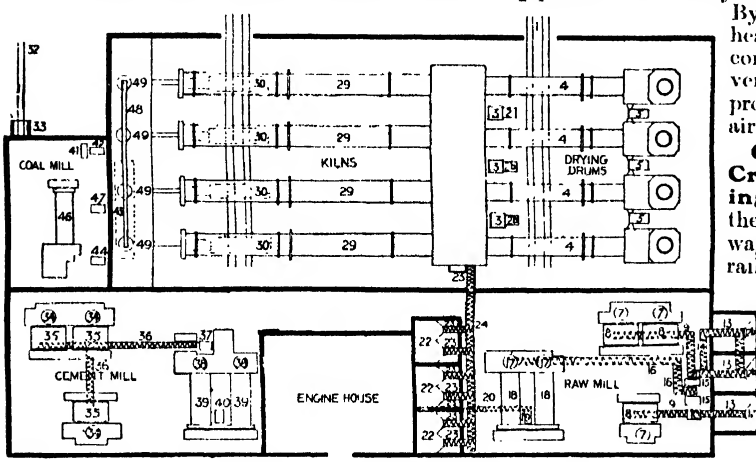
The Kilns. The four rotary kilns (29) are 30 metres, or about 100 ft. long, and 2·1 metres, or about 7 ft. in diameter. The hot clinker, which falls out of the kiln at its lower end, passes through the double clinker cooler (30), consisting of two cylinders, one inside the other. The clinker, moving along, meets a strong current of air drawn through the cooler. This air gets heated gradually to a high temperature as it is

drawn along through the brick-built room in which the drying drum for coal (43) is situated. It returns to the kiln through the fan (52).

The cool clinker falls into tip waggons (31), and is taken to the cement mill, which will be described later on.

The rotary kiln is fired by means of coal dust; this replaces coal or coke as the source of heat for burning the raw materials to clinker.

Coal Drying Plant. Special drying and grinding plant is provided for reducing the coal



18. PLAN OF A DRY-PROCESS CEMENT MILL

to dust. It is found that, as in the case of raw meal, the coal must be thoroughly dried before it can be effectively powdered.

The coal dryer, which is an important apparatus, is built in a brick-buit chamber, so that both ends jut out through the walls. The coal is fed in at one end of this dryer and leaves at the other, and at the same time a small amount of air is drawn from the hot air chamber through the dryer by means of a special little fan. The coal, as it enters the works, is fed in through an aperture in the floor (11), covered with a coarse grating to prevent big lumps from getting into the elevator inadvertently.

Coal Grinding. By this elevator (42) it is taken up to the place where it is fed into the drying drum. The dried coal falls into the elevator (44), by which it is fed into a small kominor (45). Here it undergoes a preliminary, or coarse grinding, after which it is discharged into the "feed" of the tube mill (46), where the fine grinding is effected. By the "feed" of the tube mill we understand the opening where the material is introduced or "fed" in.

The coal dust is carried up by means of the elevator (47) and distributed through the worm (48) to the four coal dust hoppers (49), one for each of the four rotary kilns. Each of these coal dust hoppers is provided with a small extracting worm, the speed of which can be easily regulated by the burner or workman who controls the kiln. This worm discharges the coal dust into a nozzle (50) through which a strong current of air is driven from small blast fans (51). This is a contrivance for sucking or forcing a current of air through a machine. We may see the principle employed in ventilating restaurants and public buildings, and we have also met with it in the process of drying bricks [see BRICKMAKING].

The blast pipe enters into the large pipe for hot air driven in from the fan (52) and discharges the coal dust in a strong blast of hot air, which actually surrounds it and forces it right into the centre of the lower end of the kiln. The two pipes are seen clearly in illustration [page 2193]. By this means the waste heat is fully utilised, and the combustion of the fuel is very complete, owing to the presence of the surplus hot air surrounding it.

Clinker Cooling, Crushing, and Grinding. The clinker falls from the coolers direct into tip waggons on the systems of rails (31), and is taken away to a clinker store arranged in the yard. Later on, it can be taken on tip waggons running on the line of rails (32), or direct from the system of rails (31) to the line of rails (32).

In both cases, tip waggons are lifted by the waggon "hoist" (33), a sort of lift, to the continuation of the line (32) on a floor above the cement mill. Here the clinker is distributed to three kominors, marked 35 in the drawing, through the feeds and feed hoppers (34). After undergoing a preliminary grinding, the coarse cement is collected by conveyers (36) and by the elevators (37), and fed into the feed hoppers (38) of the two tube mills marked on the drawing 39, in which the finishing and fine grinding takes place. An elevator (40) delivers the cement on to a "belt conveyer," not shown in the drawing, which carries the cement across to the warehouse. A belt conveyer is simply a long band or belt passing over pulleys, which keep it constantly moving. The belt is horizontal, or nearly so, between the two pulleys, and the material falling on it is carried along and tipped off at the further end. It is a contrivance used for conveying material from one part of the works to another, and can be used for a great variety of materials; we shall meet with it in grain stores, flour mills, etc.

Motor Power. For driving the machinery, two triple expansion engines of 600 h.p. each are provided. One of these drives the raw mill, and the other the cement mill; but, besides this, it is arranged that either of the two engines can drive the kiln plant, with the accessory crushing and drying plant for the raw materials, and drying and grinding plant for the coal. Then, if one engine breaks down, the other is available. This precaution is necessary, as it is of the greatest importance that the rotary kiln plant should never be stopped, for a stoppage

will mean cooling down of the kiln and serious interruption, and also damage to the firebrick lining.

Wet Process Plant. We shall take a typical installation to describe the process, just as we did in the dry process plant.

In 21 and 23 we show a large modern wet process plant. The raw materials are ordinary white chalk, containing about 25 per cent. of water in the state in which it is quarried, and gault clay, which also contains 25 per cent. of water on an average.

The raw materials are brought in on rails (1), passing the weighing machines (2), where each waggon-load is brought up to a standard weight by taking off or adding to it from a small store of raw material always at hand in the weighing-house. The weights are made up so as to correspond exactly to the proportion in which the two materials have to be mixed. They are tipped into the three wash mills (3). These are large-sized wash mills, about 25 ft. in diameter. The washing is done with the least possible quantity of water, and the slurry contains only about 33 per cent. of water to 67 per cent. of raw material. The slurry from the wash mills is pumped by three double-acting plunger pumps (4) through a system of pipes distributing the slurry evenly to the two "wet tube mills" (5). Each of these takes a charge of 10 tons of flint pebbles. The quantity of slurry which passes through these tube mills is very considerable, amounting to more than 400 tons a day.

Travels of the "Slurry." The tube mills discharge the slurry into six large triple mixing basins (6), each of which is capable of holding about 200 tons of slurry, and is no need to stop the rotary kiln plant should any breakage occur in the wash mills.

Each of the basins is provided with a slurry pump (7). All of them pump the slurry through a system of pipes ending in a standpipe (8), from whence the six kilns are fed with slurry through valves (9) and shoots (10).

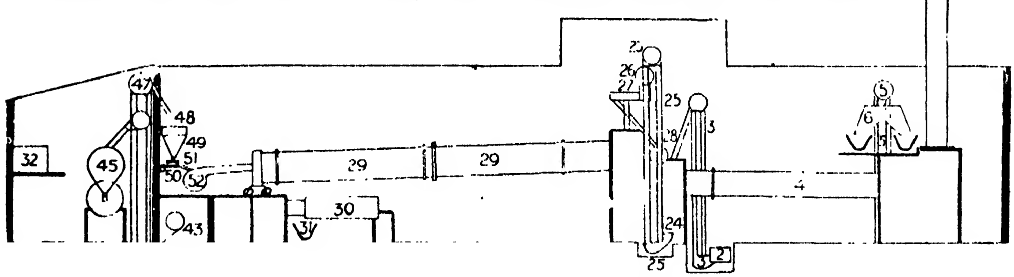
To ensure that the pressure under which the slurry flows into the kilns may remain constant, and the flow consequently regular, the standpipe (8) enters into a small tank (10), with an overflow (11) which leads back into a system of pipes, through which the overflow can be returned to any one of the six basins.

The Kilns. The six rotary kilns (12) are of the usual construction, the upper end being enclosed in a brick chamber, allowing the draught to sweep back outside the shell of the kiln before it goes away to the chimney to increase the drying capacity of this end of the kiln.

These kilns are 30 metres, or about 100 ft. long by 2·1 metres, or about 7 ft. in diameter.

From the lower end of the rotary kiln the hot clinker falls into the clinker cooler (13), shown by dotted lines under the kiln. This is of the usual type, with two cylinders, one inside the other. The cooled clinker falls into tip waggons on a system of rails (14), and is taken away to the cement store and mill.

Coal Dust Plant. The coal drying and grinding plant are of the usual construction, such as we have already described. The coal drying drums (15) are shown by dotted lines. There are three of these drums, all of them surrounded by brick-built chambers underneath the floor on



19. ELEVATION OF A DRY-PROCESS CEMENT MILL, SHOWING ONE KILN AND DRYING DRUM

fitted with three systems of agitators; they consist of vertical shafts, with "channel iron" arms revolving slowly, so as to keep the whole contents of the basins in constant movement.

The purpose of the basins is partly to mix large quantities of slurry, so as to do away with any variations in the composition of the slurry as it comes from the wash mills, and partly to provide a means of checking its composition. As a basin fills gradually, the chemist will watch it, and, if necessary, see that more clay or chalk is added to the wash mill from which the basin is being filled. When this is accomplished the contents of the basin are kept in movement until required. In this way the basins act as reserves of slurry, so that there which the burners work the kilns. The coal is fed in through three "jaw crushers" (16), one for each of the drying drums, and thence lifted by the three elevators (17) into the feeds of the drying drums.

The dried coal is lifted by the two elevators (18) into the two kominors (19), the coal from the outside drying drum being conveyed to the elevator by the worm (20).

The Kominors. The two kominors for coal are a size to take 1 ton 4 cwt. of steel balls, are provided with screens of about 20 meshes to the lineal inch, and discharge the coal direct into the two underlying tube mills (21), where the fine grinding takes place. These mills take a charge of 10 tons of flint

pebbles. The finished coal dust is elevated direct from the tube mill outlets by means of the elevators (22) into the two distributing worms (23) over the six coal dust bins (24).

The small blast fan (25) provides the blast for the injectors into which the coal dust is fed by the variable speed extracting worm in the bottom of the coal dust hoppers. The large fan (26) draws the air through the clinker cooler, the chamber in which the coal dryer is arranged, and blows the hot air into the kiln through the pipe (27) surrounding the coal blast pipe, as described previously.

Precautions for Continuous Working. It may be stated here that it is of the greatest importance to be able to run the rotary kilns practically without stoppage. For this reason, all the auxiliary machinery is made amply large enough. Two wash mills of the size given would, under usual circumstances, be sufficient for the quantity of slurry required, and the third is introduced purely as a reserve. One tube mill would be almost sufficient for the quantity of slurry to be ground, but another one has been introduced, so as to be on the safe side, and, as a rule, both work so as to ensure the greatest possible fineness of the slurry.

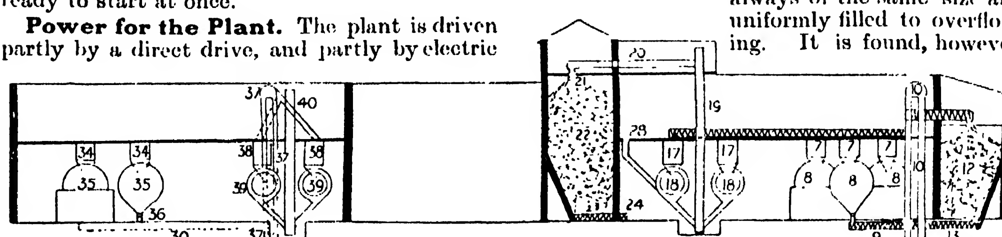
For the same reason the coal mill plant is made larger than appears necessary; one tube mill should, under ordinary circumstances, be sufficient to produce the necessary quantity of coal dust, and the other one is practically a stand-by. For the same reason all elevators and distributing worms over the coal dust hoppers have been doubled, so that if anything happens to one, there will be another always ready to start at once.

Power for the Plant. The plant is driven partly by a direct drive, and partly by electric

The arrangement of the milling plant for grinding the clinker is of much the same nature as described before in the dry process plant.

Composition of Portland Cement. We have already emphasised the importance of seeing that the ingredients, whether chalk, limestone, or clay, are in exactly the right proportions. We must take every precaution to avoid leaving any free lime in the finished cement. Lime particles would not readily slake, and the cement would be unsound; on the other hand, the amount of lime present should approximate as nearly as possible to the maximum amount allowed, and this limit is approached so closely in modern cement-making that it requires only a very little variation in the proportions of the raw materials to raise the percentage of lime to a dangerous excess. Where lime is burnt in the old-fashioned kilns it becomes mixed with a considerable amount of ash from the coal. This ash is essentially of a silicous nature, and as it combines with some of the lime to form calcium silicate, we can in such cases allow rather more lime than the theoretical amount required by the clay. On the other hand, in the rotary kilns a comparatively small quantity of ash is mixed with the ingredients, much of the fine dust being carried off in the air blast, so that in this case the proportion of lime is kept down to the ordinary limit.

Control Tests. We have explained how quantities of chalk, clay, or limestone are measured off on automatic machines, but it is more usual in the Thames and Medway districts to use all chalk by measure and clay by weight. Chalk is delivered in trucks always of the same size and uniformly filled to overflowing. It is found, however,



20. ELEVATION OF DRY-PROCESS CEMENT MILL, SHOWING KOMINORS, TUBE MILLS, AND SILOS

motor. Two steam engines are used, of the same size and construction, each of them provided with a dynamo to supply current to drive the rotary kilns and coal mill plant and pumps by electric motors. Each of them is connected with the main driving shaft which drives the wash mill plant.

Either of the machines can be connected to the main driving shaft. The pumps can be driven either by electric motors or direct from the main driving shaft. In this way every possible provision is made for working the rotary kilns uninterruptedly at all times.

If any larger repairs are necessary, they will, as a rule, be made by stopping the works once a year for a few days, and putting everything into thorough order.

that the clay is best weighed in the trucks in which it is delivered, and by keeping count of the number of trucks emptied into the mill the proportions can be easily regulated.

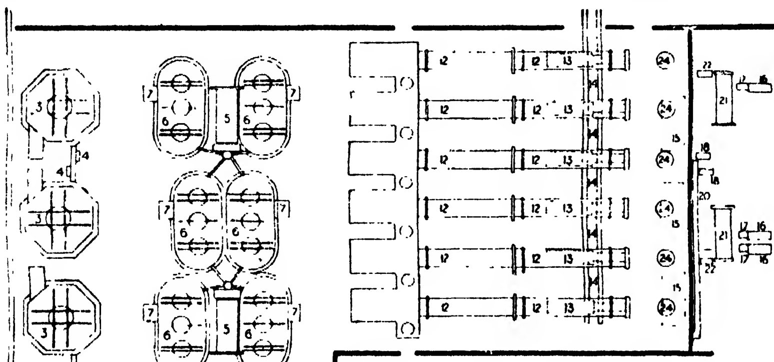
The mixed materials should always be tested by a chemist before taking to the kilns. As the mixture is stored in large reservoirs holding as much as 1,200 tons of slurry, any slight variations in the material tend to equalise themselves.

In testing slurry the amount of carbonate of lime is estimated, and it is usually found that the slurry as it leaves the reservoir does not vary to the extent of ½ per cent. The amount of calcium carbonate is tested chemically by means of some form of calcimeter. The principle of this apparatus depends on the evolution of carbon

dioxide gas when calcium carbonate is treated with an acid. A certain quantity of the slurry is put into a closed vessel and treated with a small quantity of mineral acid sufficient to decompose all the chalk or limestone contained in it. The carbon dioxide gas given off is collected and measured.

Chemistry of Cement Making. We have already explained that, under the action of the great heat developed in the kiln, certain substances known as silicates and aluminates of calcium are produced. We will trace briefly the formation of these substances.

When the materials are fed into the kiln, any water still held is driven off. Of course, if we use wet slurry direct in a rotary kiln, the whole of the water it contains evaporates during its passage down the kiln. In either case the clay withholds some water very tenaciously, and a temperature of 600° C. is necessary to drive this off completely. As the mass sinks into a hotter zone in the kiln, or passes further down the rotary kiln, the carbonate of calcium, whether of chalk or limestone, gradually loses its carbon dioxide and is converted into caustic lime before it reaches a temperature of 900° C. After this, the lime begins to react with the clay, and certain fusible substances, traces of alkaline silicates and aluminates of calcium are produced. The melting of these substances helps to bring the remainder of the lime into contact with the silica. This results in the formation of calcium silicate, which is the essential hardening constituent of the cement, but is not itself fusible in the kiln. The temperature is not uniformly high enough to fuse the whole mass and render the reaction between the constituents complete, but should any free lime be there, there will certainly be the correct proportion of clay to react with it. There is no danger of free lime rendering the cement unsound, provided that it is not present in excess, and that the clinker has been thoroughly burnt.



21. PLAN OF A WET-PROCESS CEMENT MILL

Chemical Research. A great deal of research work has been done on cements with a view to finding out in what way the elements which form the constituents are combined with one another, and what chemical substances are present in the finished cement. Most of the work done in this direction we owe either to Le Chatelier or to two American chemists, S. B. and W. B. Newberry. The latter investigators succeeded in preparing definite aluminates and silicates of lime by fusing together alumina and lime and silica and lime in certain proportions. They nvestigated the properties of the resultant compounds, and came to the conclusion that lime could be combined with silica in the proportion of three molecules to one, giving a product of constant volume and good hardening properties, although the hardening was a very slow process. If, however, they increased the proportion of lime to three and a half molecules as against one molecule of silica, the resultant product was unsound, that is to say, it cracked on setting in water. They thus isolated the tricalcium silicate ($3CaO . SiO_2$) and showed that it is capable of accounting for the hardening of Portland cement.

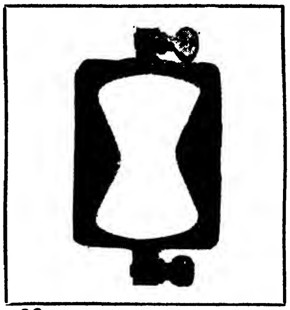
Lime and Alumina. As for the combination of lime and alumina, they found that when mixed in a proportion of two molecules of lime to one of alumina, and strongly heated, a product obtained which set rapidly—much more quickly than the tricalcium silicate. This substance we shall term dicalcium aluminate ($2CaO . Al_2O_3$). As the volume remains constant when gauged with water and allowed to set, its presence in Portland cement would account for the rapid setting, and also partially for the subsequent hardening. On increasing the amount of lime to two and a half molecules to one of alumina, the product obtained was not sound. Hence they concluded that to obtain a satisfactory cement the quantities of the ingredients must be so chosen that for every molecule of silica there are three molecules of lime, and for every molecule of alumina two molecules of lime, or, put otherwise, the percentage of lime should equal the percentage of silica multiplied by 2·8 + the percentage of alumina, multiplied by 1·1. This formula agrees pretty well with the results of analyses of numerous Portland cements manufactured in the ordinary way. The exact proportions used in practice depend on the method of manufacture, the purity of the clay, chalk or limestone deposits, and the care exercised in burning, and it is found that good cement will contain anything between 58 and 67 per cent. of lime. All cements contain a small quantity of oxide of iron, and it is a moot point whether this may or may not be regarded as replacing some of the alumina. Some authorities reckon the alumina after deducting the oxide of

iron; others neglect the latter in their calculations.

Analysis of English Portland Cement. We give below an analysis of English Portland cement, made from chalk and clay:

Silica (SiO_2)	22·04
Alumina (Al_2O_3) ..	7·35
Oxide of Iron (Fe_2O_3) ..	4·14
Lime (CaO)	61·94
Magnesia (MgO)	0·91
Soda and Potash (Na_2O. K_2O)	0·59
Sulphuric anhydride (SO_3)	1·38
Moisture and carbon dioxide (H_2O. CO_2) ..	1·65

Portland cements all the world over do not differ much in composition. Besides the three chief constituents, lime, silica, and alumina, there is always some oxide of iron, usually between 2 and 5 per cent., a trace of magnesia, usually not exceeding 2 per cent., and traces of other substances. The sulphuric anhydride should not exceed 2 per cent. As sulphate of calcium is sometimes added to prolong the time taken by the cement to set, and as its amount is usually limited by agreement to 2 per cent., the raw materials should be as free as possible from sulphates.



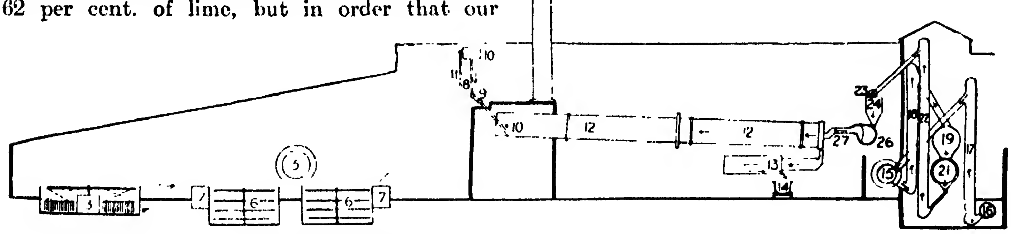
22. MOULD FOR MAKING CEMENT BRIQUETTES

Testing Cements by Chemical Analysis. Cements are very frequently analysed in the laboratory, to see if their composition is within the limits found compatible with a good cement. Thus, if the lime be found to exceed 67 per cent., we should probably reject the consignment as over-limed, or we should be very suspicious as to its durability. The engineers' specifications often fix a limit to the proportion of lime; thus, for instance, we might specify that the cement in question should contain at least 60 per cent. or not more than 62 per cent. of lime, but in order that our results may not mislead us, we must be careful to see that the sample is dry and has not been unduly exposed to air. The percentage of the ingredients changes a little if cement be spread out so as to expose a large surface to the atmosphere; this is owing to the absorption of small quantities of carbon dioxide, and moisture which reduces the apparent quantity of lime present.

As the clinker manufactured by the rotary process is more free from ash, the percentage of lime is found somewhat higher than in clinker prepared in the stationary kilns. Moreover, the reaction in the rotary kiln is more uniform, and there are no unburnt or partially burnt lumps of clinker. It is, therefore, possible to work nearer the limit—that is to say, with a higher percentage of lime than in the older process—with the result that a rather better class of material is produced.

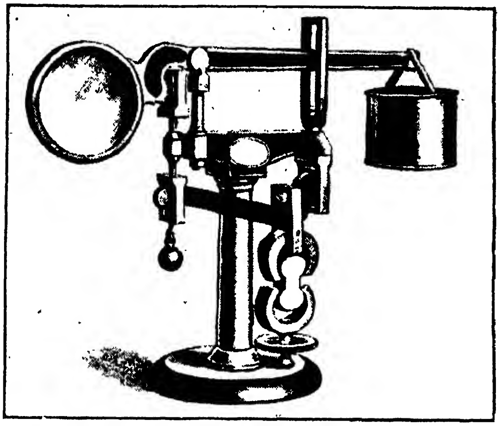
In the Laboratory. When the sample of cement comes to hand it is carefully preserved in an airtight bottle or tin, so that it cannot absorb anything from the atmosphere. If a chemical analysis is to be made, there are several modifications of the ordinary analytical methods which can be used to advantage. For most purposes it is sufficient to decompose a weighed quantity of the cement with hydrochloric acid, care being taken to see that the cement is first very finely ground. If necessary, a small quantity should be re-ground in an agate mortar before starting the analysis. After decomposing with hydrochloric acid, assisted by a few drops of nitric acid, the contents of the basin in which the operation is carried out are evaporated to dryness and "baked," to render the silica insoluble. On adding hydrochloric acid, the silica separates out, and is filtered off and weighed in the usual manner [see ANALYTICAL CHEMISTRY]. There remains in solution as chlorides the iron, aluminium, and calcium. Excess of ammonium chloride and ammonia precipitates the iron and alumina together as hydroxides. For many purposes it is not necessary to separate them, and it is sufficient to filter off the precipitate, ignite, and weigh it.

Detailed Analysis. If the amount of iron and alumina be required separately, it is better to determine the iron by itself in a fresh sample by some other method, and deduct its weight from the weight of the iron and alumina taken together, which will give the quantity of alumina. We have now determined the proportion of all the chief constituents, with the exception of the lime, which we now have in solution. To estimate its amount, it is better to precipitate it in ammoniacal solution by adding an excess of ammonium oxalate, which deposits the lime as calcium oxalate. This is collected on a filter paper, and washed thoroughly with hot water.



23. ELEVATION OF A WET-PROCESS CEMENT MILL

It may be estimated by a number of methods, for which we refer the reader to Analytical Chemistry. It is often necessary to estimate the amount of sulphuric acid to see if an excess



24. BAILEY'S CEMENT TESTER, SHOWING BRIQUETTE IN POSITION

of calcium sulphate or gypsum has been added to the cement. For this purpose we may take a filtered solution in hydrochloric acid of a fresh sample of cement, and determine the sulphuric acid by precipitating as barium sulphate in the usual manner.

Results of Chemical Analysis. The percentage of lime is not always a guide to the soundness of the cement, as a thoroughly burnt cement will stand a greater percentage of lime than an imperfectly burnt one where the temperature has not been sufficiently high to bring about complete combination of the lime and silica. It is not possible to determine the amount of uncombined lime by ordinary chemical analysis, so that its presence is only indirectly inferred by the behaviour of the cement under another test—*viz.*, that for soundness—which we shall describe later.

If the raw materials are not thoroughly ground and intimately mixed there may be incomplete chemical combination, and consequently free lime in the cement, although the percentage shown by analysis is not higher than in an average good sample.

The amount of alumina in cement may be anything between 5 and 10 per cent. As a rule the greater the proportion of alumina the quicker the "set," and the setting may be so rapid as to render it useless for many purposes. Calcium aluminate has not the peculiar hardening qualities of the silicate, so it stands to reason that with too much alumina the strength of the cement will be reduced.

All cements contain more or less iron, which is shown in the analysis as ferric oxide, although it exists in the cement in the ferrous state. The amount does not usually exceed 5 per cent., and is not regarded as harmful if kept within this limit.

Causes of Colour. The cement owes its grey colour to the iron it contains. If the cement were free from iron it would be white, so that, as in the case of bricks, the colouring is brought about by the iron present, and will vary in intensity with the amount.

As to magnesia, opinions seem to differ a good deal as to what percentage should be allowed. Many of the natural rock cements contain very large proportions of magnesia, while, on the other hand, many people object to a Portland cement containing 2 or 3 per cent., or, at most, 5 per cent. It is generally considered that the presence of magnesia tends to cause the cement to crack. The amount of alkalies should be small. They probably do not play such an important part in the manufacture of cement as was at one time generally supposed. Some cements made from alkali waste naturally contain large quantities, but a good sample of Portland cement should not contain more than 2 or 3 per cent. Usually it will be less than 1 per cent. We have already explained that gypsum is added in small quantities to get a slower setting cement, and that, in consequence, the amount of sulphuric acid is limited to 2 per cent. There seems to be no doubt that anything over 5 per cent. of calcium sulphate is injurious.

Cements usually contain traces of carbonates. Of course, if there is any quantity present, it will point to an imperfectly burned cement; but cements prepared in this country are frequently exposed to air for a fortnight or so, in order that any trace of free lime may be rendered harmless by taking up carbonic acid with the formation of calcium carbonate. The amount of carbonic acid absorbed in this manner will seldom exceed 1 per cent.

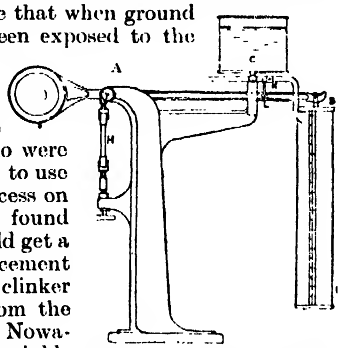
"Setting" of Cement. We must emphasise again the distinctions between the setting and the subsequent induration or hardening of cement. The test is usually carried out by mixing a small quantity of the cement with only just sufficient water to make it a uniform paste.

The pat is mixed or "gauged" as quickly as possible, and thrown on to a glass plate, so that it forms a mass 2 or 3 in. wide and, say, ¼ in. thick. It is then tested with a weighted needle applied to the surface every now and again, until it no longer makes an impression. The needle weighs 2½ lb., and is provided with a square point, measuring $\frac{1}{16}$ inch each way [28]. Although sufficient water must be taken to produce a plastic mass, an excess of water must be avoided, as the time taken to set will in that case be much altered.

Atmospheric Influence. The temperature and humidity of the surrounding atmosphere influences considerably the rate of "set." These conditions should be kept as constant as possible. A good temperature to take is that of 60° F., or 15° C., which is the ordinary temperature of the laboratory. The atmosphere should be moist, so that the water does not evaporate from the pat while it is setting. This is a point of much importance in slow-setting cements, which may take an

hour or more to set, and the pats should be a covered over to prevent evaporation.

With the increasing degree of fineness to which cements are nowadays ground, manufacturers have had some difficulty in producing a quality that would not set too fast. It has been known for a long time that when ground cement has been exposed to the atmosphere in thin layers it takes longer to set. The Americans, who were among the first to use the rotary process on a large scale, found that they could get a slower setting cement by wetting the clinker as it came from the clinker cooler. Nowadays, this is invariably effected by passing steam into the tube mill used for grinding the clinker. It is found that by carefully regulating the quantity of steam admitted the rate of "set" can be very efficiently controlled.



25. BAILEY AND REID'S CEMENT TESTER

How Fine is Cement Ground? Not very many years ago manufacturers were content to produce cement sufficiently finely ground not to leave more than 15 per cent. residue on a 50-mesh sieve. Nowadays a residue not exceeding 15 per cent. on a 180-mesh sieve is the usual standard. When we speak of a 50-mesh sieve, we mean one in which you may count 50 wires to the lineal inch, and as there will be another 50 wires crossing these to make one square inch of the wire gauze, there will be 50×50, or 2500 holes altogether in the sq. in.

The same considerations apply to 75, 100, and 180-mesh sieves, which are those usually used for testing cement.

The Mesh of the Sieve. Now, the size of the hole in a sieve of any particular mesh will depend upon the thickness of the wire. The thicker the wire, naturally the smaller the holes, so that it is important to use a standard wire in making these sieves. It is so arranged that whatever be the mesh of the sieve, the diameter of the wire shall be just equal to half the space between the wires. Thus, taking, say, a 100-mesh sieve with 10,000 holes, the space in one lineal inch will occupy two-thirds of an inch, and the 100 wires, if placed together, will occupy one-third of an inch, so that the diameter of the wire in a 100-mesh sieve will be $\frac{1}{300}$ inch.

Bamber gives the following figures for the fineness of cement in ordinary practice:

Mesh.	Residue left in sieve.
50 (2,500 per sq. in.)	Trace per cent residue.
76 (5,776 ,, ,,)	1 to 2 ,, ,, ,,
100 (10,000 ,, ,,)	3 to 5 ,, ,, ,,
180 (32,400 ,, ,,)	15 to 20 ,, ,, ,,

When testing cement in this manner it is usual to take 100 grammes of the cement and to weigh what remains on the sieve, and not that which passes through, as some of the latter, being ground to the finest dust, would be lost.

Specific Gravity of Cement. This test is useful in detecting some adulterants. It is found that the specific gravity varies little from the figure 3·125, and should it differ from this, you may suspect the addition of some inert material. As examples of such adulterants, we may mention a rock known as "Kentish rag," which is not unlike cement itself in appearance, but has a much lower specific gravity. It used to be regularly added to cement—in fact, some people asserted that cement was thereby improved. This view is now generally discredited. Ground blast furnace slag is another adulterant which closely resembles Portland cement, both in colour and chemical composition.

Density and Quality. Imperfectly or under-burned cement will be lighter and have a lower specific gravity than properly burned material. The test is usually performed in a specially designed bottle, with a graduated neck, and depends upon the principle that equal weights of bodies of different specific gravity occupy different volumes. The bottle, which holds 50 to 60 cc., is filled with dry turpentine to a given point marked on the neck. A weighed quantity of cement is then added. The volume of turpentine displaced by the cement will be apparent by the extra volume occupied by the turpentine in the graduated bottle. Two precautions must be observed in making this test: first, care must be taken to see that no air bubbles hang to the particles of cement, but that they are thoroughly "wetted" by the turpentine; secondly, turpentine expands a good deal with rise of temperature, so that the temperature must not be allowed to vary during the experiment. It is best to immerse the bottle and the turpentine in water, at, say, 60° F., until the turpentine attains exactly the same temperature as the surrounding water.

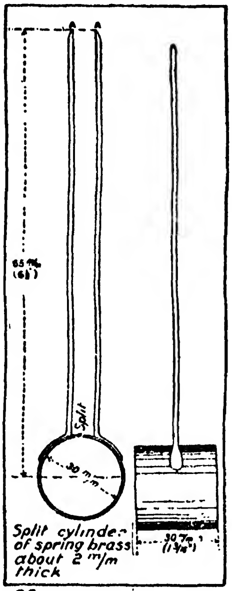
After adding the cement to the bottle, it is again immersed in the same water long enough to enable the temperature to become constant before the next reading is taken.

Testing the Strength of Cement. As cement is usually employed in admixture with sand in the form of mortar or concrete, it is usual to test the strength not only of the neat cement, but of cement mixed with three parts of sand. We may either determine the power required to crush a block by compressing it, or break it by pulling it in two. Although the former method corresponds better to the conditions to which cement is exposed in practice, it is a more difficult operation to carry out than the latter method—testing tensile strength—so that most of the testing machines and the cement specifications are based on, and apply to, the tensile strength. For this purpose, a weighed quantity of cement is gauged with as small a quantity of water as possible, and filled into a mould shaped in outline somewhat like a dumb-bell [22]. The mould is first slightly greased to prevent the cement from sticking as it sets. A number of moulds are similarly filled

up with cement, for which it is better to gauge each lot of material separately. The moulds are made of definite size and dimensions, so as to give uniform results.

When set, the "briquettes" are taken out of the moulds and tested under different conditions. A special sand from Leighton Buzzard is used for making mixtures with cement, or else crushed quartz, and of such a degree of fineness that the whole will pass through a 20-mesh sieve and be retained by a 30-mesh sieve.

The Testing Machines. When the briquettes have set they are immersed in water for 24 hours before testing. Others are kept seven days and longer. It is usual to have several briquettes and test them regularly at different intervals. Although the narrowest part of the briquette is frequently only 1 in. across, the power required to break such a briquette is considerable. The instrument used is made up of either a single lever or a combination of levers. The block is held between clips [24], and by means of a double lever great force is applied. It is essential that the power be applied regularly, and this is done by running either water or small shot at a regular rate into a pan hanging at the end of the second lever. By an automatic arrangement, not shown in 24, the supply of shot is cut off directly the briquette breaks. The can full of shot is then taken to a balance and weighed. By multiplying this weight by the ratios for the leverage we obtain the power required to break the briquette under examination. A good, average sample of cement will give figures somewhat as follows:



26. APPARATUS FOR LE CHATELIER TEST

TENSILE STRENGTH: NEAT				
1 day	7 days	14 days	28 days	6 months
Av. 201 lb.	462 lb.	485 lb.	553 lb.	754 lb.

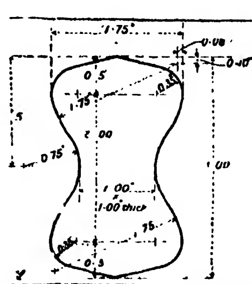
ONE PART CEMENT TO THREE PARTS SAND			
7 days	14 days	28 days	6 months
Av 116 lb.	125 lb.	163 lb.	268 lb.

Fig. 25 shows Bailey & Reid's machine for testing the tensile strength of cement. It is built with one lever AB instead of two, and the strain is applied by running water from the small cistern C into the long graduated can DE. In this manner the strain is increased gradually and in a very regular manner without any vibration. When the briquette shown at H breaks, and the end B of the lever begins to sink, the supply of water to the can is cut off automatically at K by the attachment or trigger L. To read the instrument it is simply necessary to note the height of water in the can DE, for which purpose it is fitted with a gauge-glass and graduated.

Is the Cement Sound? We come now, lastly, to perhaps the most important test of all—the test for soundness.

The tensile strength may be exceedingly high, but, unless sound, the cement is worthless. It often takes some time for cement which is unsound to develop suspicious indications, and the tests for soundness are often designed with a view to producing artificially the effect of age. Some cements rapidly develop faulty qualities, and the simplest test is to immerse the pat in water for 24 hours as soon as it is thoroughly set, while leaving a similar pat exposed to the air. Both pats are carefully examined from time to time to see if there are any indications of cracking due to expansion of the mass after it has once set. If the cement will not stand this simple test it is to be condemned unhesitatingly. On the other hand, there are certain appearances which occasionally mislead. Thus, should some of the water evaporate before the cement sets, which may easily happen with a slow-setting cement, the pat may show certain contraction cracks although the cement is perfectly sound, so that in examining slow-setting cements care must be taken to prevent the moisture evaporating before the cement has set, by keeping the pats under a cover.

Exacting Tests. It is usual to apply more stringent tests for soundness. There are many modifications of the method applied, but in principle it consists in placing in water the pats, which have been given time to set, and gradually heating up the water. This will bring out in a pronounced manner any tendency to crack, as any free lime is far more rapidly slaked under these conditions.

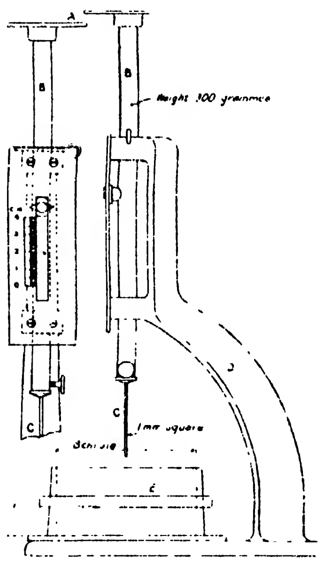


27. STANDARD BRIQUETTE FOR TESTING

When a very stringent test is required, the actual expansion in warm water may be measured by Le Chatelier's apparatus [26]. This consists of a small cylinder of brass split down the middle so as to be elastic. Sufficient cement is "gauged" to fill the cylinder, which stands upright on a glass plate. It is covered with another glass plate, and left 24 hours to itself. Each side of the split cylinder is provided with a long pointer, and the cylinder containing the cement, which has now had time to set, is placed in water at a temperature of about 60° F., and left for 24

hours. The distance between the indicator points is carefully noted. The water is then gradually heated until it boils, and is kept boiling for six hours. After cooling, the distance between the indicator points is again measured; and if any expansion has taken place it will be immediately apparent. Cement capable of standing this stringent test may be considered perfectly satisfactory, and even cements which show slight expansion under these conditions are often good enough for most purposes.

Standard Quality. The Engineering Standards Committee issued in 1904 a Standard Specification for Portland Cement. This report was revised in August, 1910. As the conditions laid down by the committee are of paramount importance, both to cement makers and cement users, we give, by permission, some quotations from this Standard Specification bearing on the important points. All those who are interested in the matter are advised to purchase a copy of the report, which may be obtained from the offices of the Committee, 28, Victoria Street, London, S.W.



28. VICAT NEEDLE FOR ASCERTAINING SETTING-TIME OF CEMENT
By courtesy of the Engineering Standards Committee

"No addition of any material shall be made after burning, other than calcium sulphate or water, or both, and then only if desired by the vendor and not prohibited in writing by the purchaser." The amount of water or calcium sulphate allowed is 2 per cent. Special precautions are to be taken with regard to the sample, so as to obtain a representative portion of the whole. "When more than 250 tons of cement is to be sampled at one time, separate samples shall be taken from each 250 tons, or part thereof."

Fineness of Grinding. The cement is to be ground so as to comply with the following degrees of firmness—namely, the residue on a sieve 180 × 180=32,400 meshes per sq. in. shall not exceed 18 per cent., and the residue on a sieve 76 × 76=5776 meshes per sq. in. shall not exceed 3 per cent.

The sieves shall be prepared from standard wire, and the size of the wire for the 5776 mesh shall be ·0044 in.; and for the 32,400 mesh ·002 in. The wire shall be woven (not twilled).

The specific gravity of the cement, when fresh burnt and ground, shall be not less than 3.15 when sampled at the works, or 3·10 provided that the vendor satisfies the purchaser that the cement has been ground for not less than four weeks. The proportion of lime to silica and alumina shall not be greater than 2·85 or less than 2·0 (calculated in chemical equivalents), represented by $\frac{CaO}{SiO_2 + Al_2O_3} = 2{\cdot}85$. The percentage of insoluble residue, it is stated, should not exceed 1·5 per cent., the magnesia should not exceed 3 per cent., and the sulphuric anhydride 2·75 per cent.

Exact details are given for the preparation of the briquette for testing tensile strength.

The briquette, some of the dimensions of which are given in Fig. **27**, is to be placed "in a damp atmosphere for 24 hours after gauging," after which it is to remain in fresh water until required for breaking; the temperature of the water to be maintained between 58° and 64° F., and the water to be renewed every 7 days.

The average breaking stress of the briquettes made from neat cement 7 days after gauging must not be less than 400 lb. per sq. in. of section.

The average breaking stress of the briquettes 28 days after gauging must show an increase on the breaking stress at 7 days after gauging of not less than:

Increase breaking stress	When 7-day test is above	And not above
25 per cent.	400 lb.	450 lb.
20 ..	450 ..	500 ..
15 ..	500 ..	550 ..
10 ..	550 ..	600 ..
	600 ..	

Testing Sand and Cement. The cement shall be tested by submitting to a tensile stress briquettes prepared from one part by weight of cement to three parts by weight of dry standard sand, the said briquettes being of the shape described for the neat cement tests.

The average breaking stress of the cement and sand briquettes 7 days after gauging must be not less than 150 lb. per sq. in. of section.

The average breaking stress of the briquettes 28 days after gauging must be not less than 250 lb. per sq. in. of section, and the increase in the breaking stress from 7 to 28 days not less than:

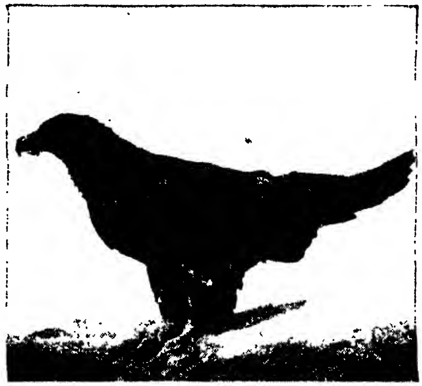
Increase of breaking stress	When 7-day test is above	And not above
25 per cent.	200 lb.	250 lb.
15 ,,	250 ..	300 ..
10 ..	300 ..	350 ..
5 ..	350 ..	

Quick, medium, and slow setting cements are defined below. The needle for testing the set of the cement [**28**], and also the Le Chatelier method of testing for soundness [**26**], both already referred to, are the standard machines adopted by the British Standard Specification.

Variety of set	Setting Time	
	Initial	Final
"Quick," not less than	2 min.	between 10–30 min.
"Medium" ,, ,,	10 ..	,, ½–2 hours
"Slow" ,, ,,	20 ,,	,, 1–7 ,,

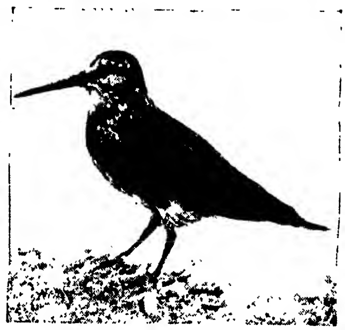
SOME QUAINT AND CURIOUS BIRDS

GREEN PARRAQUET



LAMMERGEIER VULTURE

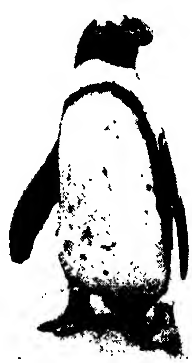
KEA PARROT



JACK SNIPE

KESTREL AND ITS PREY

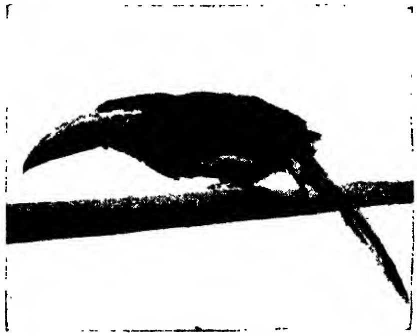
GOLIATH HERON



CAPE PENGUIN

SECRETARY VULTURE

BLACK SWAN



ARACARI TOUCAN

STILTED PLOVER

Carnivorous and Vegetarian Birds. Hoppers, Walkers, Runners, and Climbers. Organs of Flight. Swimming and Diving Birds.

FEEDING AND MOVEMENT OF BIRDS

Birds of Prey. Eagles, falcons, hawks, harriers, buzzards, and the like are adapted for the pursuit of prey not only by possession of strong, hooked beaks, powerful talons, and keen powers of vision, but also by the swiftness of their flight. Many of them—for example, falcons—are able to poise themselves, apparently motionless, in the air till some such prey as a young rabbit or small bird is discovered, and then swoop down upon the victim with almost incredible rapidity.

Carrion Eaters. The carrion-feeding vultures are able to detect dead animals from very considerable distances by means of their keen sight, and are extremely gluttonous. The little Egyptian vulture (*Neophron percnopterus*) of North Africa, India, and part of Europe is said to devote its attention to the bones of carcases which have been picked clean by other carrion eaters. In Spain it is known as the "quebrantahuesos" (bone-smasher), because it breaks bones by carrying them to a height in the air and letting them fall on rocks. A similar habit is attributed to the bearded vulture, or lammergeier (*Gypaetus barbatus*), and possibly tortoises may be cracked in the same rough-and-ready manner.

The Snake's Foe. The curious African secretary bird (*Serpentarius secretarius*) is a long-legged form which pursues all sorts of small animals on the ground, and is particularly partial to snakes. The reptile is assailed with simultaneous blows from legs and wings, the latter also serving as a shield. In South Africa the bird is often tamed, rendering valuable service by the war it wages upon poisonous serpents. Owls avoid competition with the ordinary birds of prey by feeding at dusk and dark, such small creatures as rats and mice bulking largely in their diet.

Insect-eaters. The tribe of insects supplies many birds with food. Swifts, swallows, and martins hawk for them on the wing during the day, and nightjars pursue them in the gloaming. Tits, creepers, nut-hatches, and the like hunt them on trees, where also they are exposed to attacks from the powerful beaks of woodpeckers. Caterpillars are eagerly sought out by many small birds; and those which are too well protected by bristles to suit ordinary digestions are acceptable to the cuckoo. The grubs and pupæ of insects which live in the soil are probed for by many strong-billed birds, and insects in all stages inhabiting fresh water are by no means free from the ravages of wagtails and many other feathered enemies.

Fish Feeders. Fishes, again, are a very favourite kind of food with numerous birds. Sea-eagles and ospreys live mostly upon them, and the same is true of large numbers of aquatic forms. In average cases the beak of a fish-eater is elongated and tapering, often with a bent or hooked tip, as seen in the black cormorant, which fishes along the coast. Gulls and their allies go farther from the land, and the albatross affects the open ocean. Nor are fresh-water fishes free from foes. Long-legged waders, such as herons, angle for them in the shallows, and kingfishers pounce down upon them from branches overhanging streams.

Some birds, such as the divers, are able to pursue their finny prey a great or less distance under water, and this habit is carried to an extreme in the penguins, the wings of which have been converted into efficient paddles.

Worm-eaters. Worms of all sorts figure in the dietary of a host of birds, some of which possess long beaks adapted to probe for them in the earth, as well seen in the woodcock. The same is true of the kiwi of New Zealand, and here the nostrils are at the end of the long beak instead of at its base, this being apparently an arrangement for smelling out the wriggling prey.

Shell-fish of various kind are also used as food by a number of birds. Gulls ravage cockle-beds, and the oyster-catcher, or sea-pie (*Hæmatopus ostralegus*), hunts for molluscs (and crustaceans) on the shore. The snails and slugs of the land and the snails of fresh water receive many attentions at the beaks of their enemies, and the thrush has learnt the art of cracking the hard shells of snails on some suitable stone, to which it returns again and again with fresh victims.

The broad bills of ducks and swans, which are adapted for feeding upon small worms and snails contained in mud, have extremely sensitive edges, and also a number of transverse ridges that serve as a sort of strainer. In geese these ridges are of use for cutting through herbage, while the mergansers find them helpful in securing fish.

In birds which affect a mixed diet, or feed on soft vegetable food, the beak is commonly a moderately long cone. Seed-eating birds, such as finches, possess short, strong, conical beaks.

Digestive Organs. As an example of the internal digestive arrangements in birds which swallow a good deal of hard food, we may conveniently take the domestic pigeon. Here the gullet is swollen into a large crop, the inflation of which gives such a peculiar appearance to a pouter. It is used for temporary storage, and passes into a somewhat oval, chemical stomach, from the lining of which the gastric juice is poured out. Then follows a rounded gizzard or mechanical stomach, with extremely thick, muscular walls and a tough lining. This organ makes up for the absence of teeth, for it rhyth-

mically contracts and dilates, thus bringing pressure to bear upon the food contained within it. Small stones and other hard objects are constantly being swallowed, which pass into the gizzard, there to play the part of millstones.

Hopping, Walking, and Running Birds. Adaptation to flight has profoundly affected the structure of birds in a large number of ways, some of which may be gathered from the appended illustration of the skeleton of a fowl. Of course, most of these peculiarities are still possessed by birds, such as ostriches, which have lost the power of flight. The somewhat boat-shaped body is supported by a strong, bony framework, which allows of but little movement from side to side, largely because the joints of the backbone are here, for the most part, closely fused together. The inconvenience of this arrangement is compensated for by the fact that the neck is long and very flexible, as must have been observed by anyone who has taken the trouble to watch a living bird. Some of the joints of the short tail are free, but those at the end have fused into a ploughshare bone for the support of the quill feathers of that region.

THE SKELETON OF A FOWL

The Limbs. The breastbone (sternum) possesses a large, projecting keel to which the muscles of flight are attached. The shoulder-girdle, to which the wing is jointed on, consists of three bones, one of which is the collar-bone (clavicle), united with its fellow to make up the familiar merrythought, which serves as a spring to keep the wings well apart. In the wing itself there are but three digits, the fourth and fifth fingers having disappeared.

Owing to the conversion of the fore-limbs into wings, the hind-limbs are set on far forward, so that the body may balance properly upon them. And, for their support, there are very long hip-bones united to a region of the backbone (sacrum) composed of a number of its joints fused together. In order to further rapid progression when on the ground, the legs are fairly long, and this has been brought about much in the same way as in ruminant mammals. Beginning at the upper end, there is a rather short thigh-bone (humerus), followed by a long shin-bone, an elongated shank-bone—comparable to the cannon-bone of a ruminant—and four toes. The little toe has been lost. It will be seen that the bird walks on its toes—that is, is *digitigrade*, just like a hoofed animal.

The ankle is therefore raised off the ground, and corresponds in position to the junction between shin-bone and shank-bone. No little, irregular ankle-bones are to be seen here, however, for in the interest of firmness half of them have united with the lower end of the shin-bone, and half with the upper end of the shank-bone. The instep-bones of the second, third, and fourth toes are fused, to make up most of the latter.

Methods of Progression. Most small birds hop; some, like the jackdaw, both hop and walk, while others, such as game-birds, waders, and rooks, walk. In the flightless running birds, some of which vie with the fleetest mammals in speed, not only are the legs of great length, but we find instances of reduction in the number of toes, already remarked among such forms as ruminants. The American ostrich has only three toes, and the African ostrich but two, of which the inner one (third) is much larger than the other (fourth). The absence of a keel to the breast-bone is also a noticeable feature.

Climbing Birds. In many cases the foot of a perching bird is a grasping organ of sufficient power to be used in climbing without any structural modification. The sharp claws naturally play an important part here. Tits and nut-hatches run up and down the trunks and branches of trees with equal facility. The writer has seen a nut-hatch alight on the surface of a plastered wall, holding on to the slightest irregularities, and maintaining itself in the same position—head downward—for some time, without any apparent effort. When climbing upward, the short, strong tail of the nut-hatch can be used as a prop, and the same is true in a greater degree of the tree-creeper (*Certhia familiaris*), which, when searching for food, regularly begins at the bottom of a wall or tree, and gradually works its way upward.

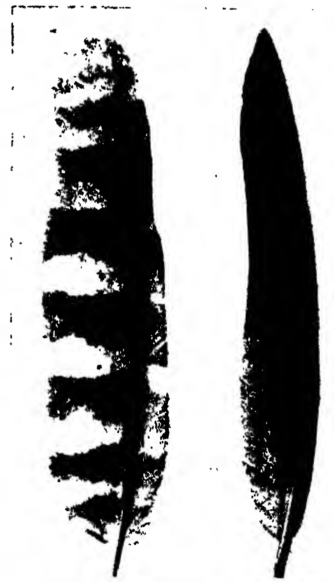
In woodpeckers and parrots, the fourth as well as the first toe is turned backward, thus constituting a specialised climbing foot. Some of the woodpeckers have gone further, and have become three-toed by loss of the first digit, while the fourth has become correspondingly efficient.

THE BIRD'S WONDERFUL ORGANS OF FLIGHT

FEATHER AND ITS AFTER-SHAFT

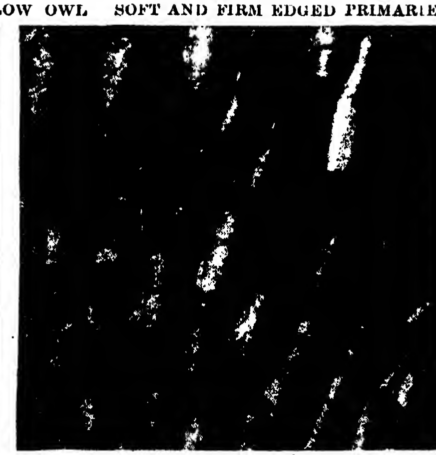
THE OUTSPREAD WING OF A CHAFFINCH

THE WINGS OF THE SWIFT WOOD-PIGEON AND THE SLOW OWL



SOFT AND FIRM EDGED PRIMARIES

THE OUTSPREAD TAIL OF A CHAFFINCH

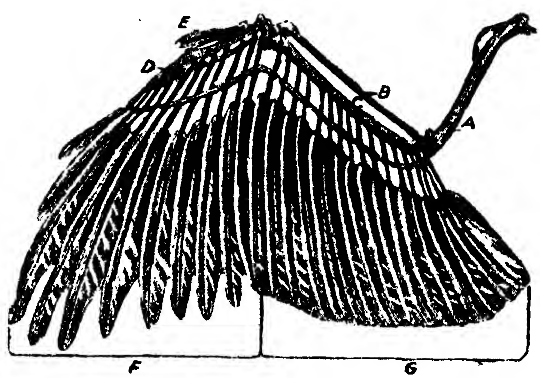


HOW THE QUILLS FIT INTO THE SKIN

The hooked beak of a parrot is as useful in climbing as in feeding.

Flight of Birds. Some of the special points in the structure of birds having relation to flight have already been mentioned, but there are still others which demand consideration. The specific gravity of the body is less than in mammals, partly owing to the light and spongy nature of the bones, many of which contain air-spaces. There are also a number of membranous air-sacs in connection with the lungs, by which the same end is furthered. But, in spite of all this, flying involves the expenditure of a vast amount of energy, in correspondence with which we find that the circulatory and respiratory organs of birds are of extreme efficiency.

The Nature of Feathers. The surface brought to bear against the air in flight is not a membrane, as in bats, but that offered by the quill-feathers of the wings, which together form an area of very large extent in proportion to the bulk of the bird. These feathers present the necessary combination of lightness and strength, together with the requisite flexibility. Examining one of them attentively, we shall see that the hollow quill at the base is continued as the axis of an expanded vane, the numerous side branches of which (barbs) adhere closely together. The reason of this becomes apparent on looking at some barbs under the microscope, for these will be found to bear still smaller branches (barbules), beset with interlocking hooks. It is the absence of these which causes the plumes of an ostrich or emu to be of such loose texture.



THE WING OF A BIRD

A, humerus; B, radius; C, ulna; D, hand; E, bastard F, primary quills; G, secondary quills.

Attachment of Wings. While in a bat the fingers are much elongated to support the flying membrane, the opposite is true of a bird, in which a firm support is required for the wing quills, sometimes called the rowing feathers (*remiges*). In the structure of the wing we notice a short, strong, upper-arm bone (humerus), which is succeeded by the two supports of the forearm (radius and ulna), of which one (ulna) bears what are known as the secondary quills. There is a good deal of fusion in the bones of the hand, which consists of only three digits. One of these, the thumb, bears a tuft of feathers known as the bastard wing, which probably helps in the execution of turning movements, while the two others support the primary quills.

The mechanics of flight is a difficult matter, and can only be treated quite briefly here. The motive power for the effective down-stroke of the wings is supplied by very large muscles, which make up most of the flesh of the breast. Here, too, are situated the weaker muscles which raise the wings, their tendons passing over a sort of pulley to be attached to the upper side of the bone of the upper arm. The wing is pulled down with its under surface sloping upward and backward, and part of the force expended goes to support the bird in the air; the other part to propel it forward.

During the downward stroke the wing quills are so pressed together as to offer a continuous surface, but, when the wing is raised, air is allowed to pass between them, so as to enable the movement to be executed with as little expenditure of energy as possible.

The radiating quills attached to the stumpy tail are known as the steering feathers (*rectrices*), on account of the function they perform. By means of appropriate muscles, they can be moved in various ways so as to direct the course of flight, whether straight forward, obliquely upward, or otherwise. A bird can use its wings as a parachute for the purposes of gliding in various directions, the simplest case being that of descent. The end of an unsuccessful swoop in a bird of prey, or a corresponding downward movement in other forms, can be converted into an upward glide, much as in the case of the parachuting movements already described for "flying" squirrels.

Some birds, such as vultures, eagles, and crows, are able to sail or soar upward to all appearance without moving their wings, describing spirals as they do so. An immense height is sometimes attained.

Swimming and Diving Birds. The feet of many aquatic birds are converted into effective paddles by the development of a strong web between the toes. This may be seen in a duck or a gull, where the three front toes are so connected, and still better in a cormorant, where all four toes are united by webs. In grebes the same purpose is answered to some extent by lobed membranous margins to the individual toes. When these swimming feet are moved forward, they fold up, so as to present as little resistance to the water as possible. With increasing efficiency in swimming powers the legs are shifted further and further back, which diminishes their efficiency as walking organs. This peculiarity reaches its extreme limit in the penguins, which are more at home in the water than anywhere else. Here, too, the wings are of no use for flight, but are converted into effective propellers, moved with a screw-like action, and covered by scale-like feathers.

J. R. AINSWORTH-DAVIS

RARE AND FAMILIAR BIRDS OF BRITAIN

CRESTED TIT

NUTHATCH

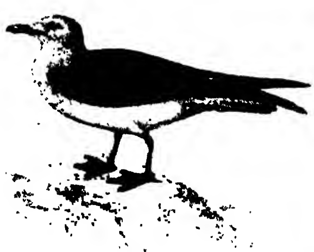
GREAT TIT

GREENLAND FALCON

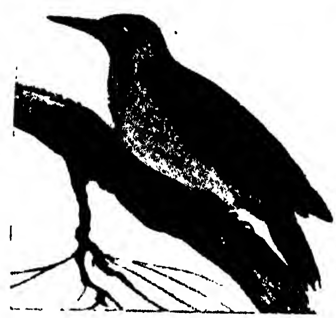
COMMON BITTERN

SNOWY OWL

EGYPTIAN VULTURE



COMMON GULL



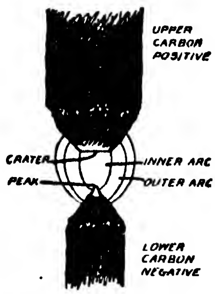
GREEN WOODPECKER

SCAUP DUCK

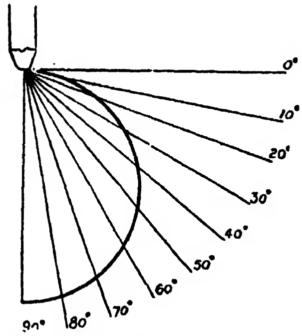
HOODED MERGANSER

OYSTER-CATCHER

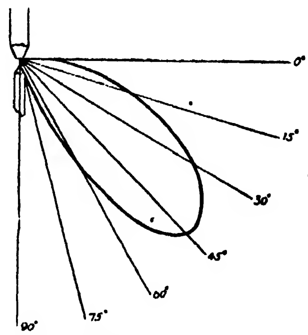
189. DAVY'S ARC



190. CONTINUOUS CURRENT ARC

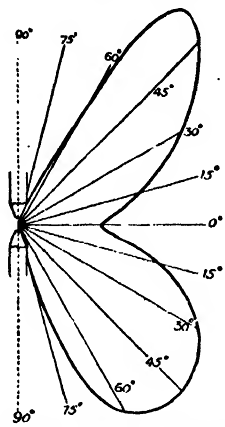


191. DISTRIBUTION OF LIGHT FROM CRATER

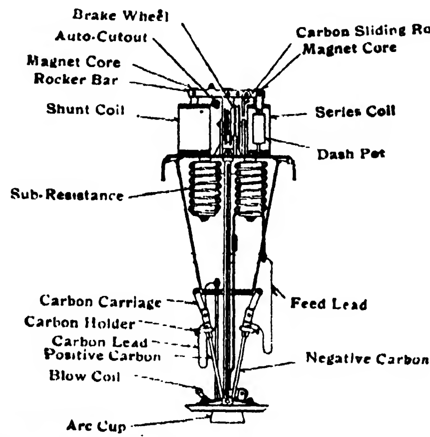


192. DISTRIBUTION OF LIGHT FROM C.C. ARC

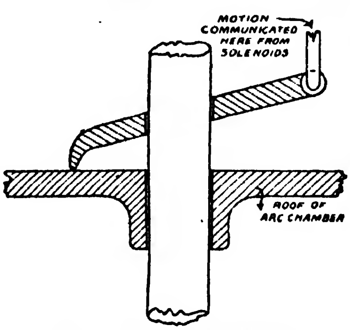
193. SKETCH OF ENCLOSED ARC



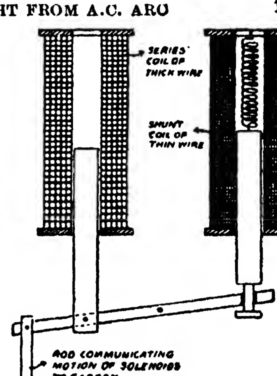
194. DISTRIBUTION OF LIGHT FROM A.C. ARC



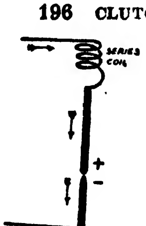
195. FLAME ARC LAMP, SHOWING BRAKE-WHEEL MECHANISM



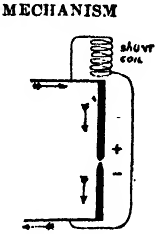
196 CLUTCH MECHANISM



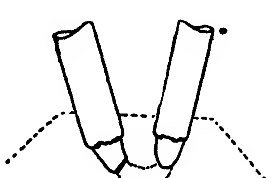
197. SEE-SAW MECHANISM



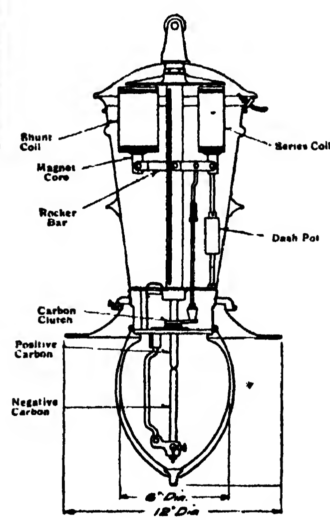
198. DIAGRAM OF CONTROL OF ARC BY SERIES E.M.



199. DIAGRAM OF CONTROL OF ARC BY SHUNT E.M.



200. ARC OF FLAME LAMP



201. OPEN-TYPE LAMP

189-201. THE PRINCIPLES AND MECHANISMS OF ARC LAMPS

The Electric Arc. Distribution of Light. Inverted, Enclosed, and Alternating Current Arcs. Arc Lamp Mechanisms.

ARC LAMPS

One of the first fruits of Volta's invention of the pile for generating continuous currents, in 1800, was Davy's discovery of the arc. He experimented on the spark that is produced between the ends of two wires through which the current from a pile, or battery of cells, is flowing when the wires are suddenly parted from one another, and observed that the spark produced between two pieces of boxwood charcoal is brighter than that between the tips of two metallic wires. Using more powerful batteries, he found that if the tips of the two pieces of charcoal are not withdrawn too far apart, the spark becomes a persistent flame. In his experiments the two pieces of charcoal were held horizontally, and the flame so produced formed an arch between them, being drawn upward by the ascending air. This electric flame he called *the arc*. If produced thus with wood charcoal, the material disintegrates into the flame, which becomes itself extremely brilliant, though unsteady. Using a battery of several hundred cells, he was able to draw out the arc to the length of several inches [**189**].

Forty years later, Foucault substituted for wood charcoal pencils of hard graphitic carbon of the kind which is found encrusting gas retorts, and which is used in making carbon plates for batteries. If this substance be ground up to powder, purified, mixed with a small quantity of tar to bind it together, compressed by hydraulic pressure into rods, and baked in closed crucibles at a bright-red heat, the resulting pencils are hard and graphitic, and conduct well. A rod 0·5 in. in diameter has a resistance of about $\frac{1}{10}$ ohm per foot. Such pencils, of different sizes according to the current to be carried, are used in arc lamps.

Arcs of Various Kinds. In modern arc lamps the carbons are seldom disposed horizontally, as in Davy's arc, though this arrangement is still used in some forms of searchlights at sea. The several arrangements in general use are:

Vertical arcs; inverted arcs; enclosed arcs; alternate-current arcs; flame arcs.

By far the most useful of these is the vertical arc supplied with a continuous current. The carbons stand vertically over one another, separated by about $\frac{1}{8}$ in., and the current flows downward, the positive carbon being above and the negative carbon below. It will be convenient to state the properties of this kind of arc first before we discuss the other forms.

Properties of the Arc. Suppose a carbon rod 0·7 in. in diameter to be held vertically in a convenient holder so that it can be moved up and down and clamped at any point. Below it let there be placed in a line with it another slightly thinner carbon rod, say 0·475 in. in diameter. Let the upper one be joined to the positive main, and the lower one to the negative main. The voltage of these mains should be not less than 60 nor more than 100 volts, and a set of adjustable resistance wires should be inserted in the circuit to regulate the amount of current. Suppose, now, the tips of the two carbons be made slowly to approach toward one another, it will be found that nothing happens unless they are actually brought into contact. Even when the air gap between them is no thicker than a visiting-card, the arc will not start of itself. To *strike* the arc, the carbons must be brought for an instant into actual contact, and then drawn back till they are separated by about $\frac{1}{8}$ in. At once the light flashes out as the arc forms itself, resembling the picture in **190**.

On examining the arc through dark glasses—to prevent injury to the eyes—or by projecting an image of it on the wall with a lens, several points will be noticed. The flame itself gives almost no light, and consists of an inner core of pale violet colour, surrounded by an outer envelope of a greener tint. A dazzling white light is given out from the bottom end of the upper carbon, and a less amount from the top end of the lower carbon. In fact, the source of the light is the surfaces of the white-hot tips of the carbon rods. These gradually burn away and assume the shapes shown in the figure. The positive carbon assumes the form of a cone truncated at the bottom. The conical part glows red-hot, but the bottom surface, which is hollowed to a sort of *crater*, glows white-hot. The negative carbon is also coned, and acquires a projecting peak, the tip of which is white-hot. Nearly all the light comes from the positive *crater*, and therefore the main light of the arc is thrown downward. The temperature of the crater is about 3500° C.; that of the negative peak about 2700° C.

Instability of the Arc. The arc, being a flame, is liable to be blown aside by currents of air, hence it must be protected by a glass globe. It can also be deflected on one side by a magnet, because it is a flexible conductor of the current. If the carbons are moved farther apart the arc becomes unsteady, and if moved more than about $\frac{1}{2}$ in. apart, goes out, and will not re-form until the carbons are brought again into contact with each other. If higher voltages are used, the arc can be drawn out longer, but in this there is little advantage. If the carbons are brought very near together without touching, the arc hisses and becomes unsteady, while nodules of carbon, called "mushrooms," form on the negative peak.

Experiments have shown that the voltage necessary with continuous currents to maintain a steady arc may be divided into two parts, one fixed part of 39 volts, and one variable part which varies with the current and is usually 6 or 7 volts for a 10 ampere arc. Many conjectures have been made as to the reason why this 39 volts is necessary, the most probable being that it is due to the resistance of a film of pure carbon vapour which forms over the crater surface of the positive carbon. Although 45 volts will maintain an arc, it is found advisable in practice always to allow not less than 60 or 65 volts, the 15 or 20 volts difference being absorbed in a resistance. This helps to keep the arc steady, and is called the *ballasting resistance*.

Distribution of Light from the Arc. The size of the crater that emits the light is nearly proportional to the number of amperes flowing through the arc. With a 10-ampere current the crater has about $\frac{1}{50}$ of a square inch of surface, and therefore a diameter of about 0·16 in. A circle of white-hot carbon of this size would emit in the direction normal to its surface a light about equal to 2000 candles. But in oblique directions the light would be less in proportion to the cosines of the angles; and moreover in the actual case the negative carbon gets in the way and casts a shadow downward. Hence the light is greatest in an oblique direction, and from an arc of this size is less than 2000 candles in the maximum direction, and is indeed less than 800 candles if the average value in all directions is reckoned. If the negative carbon did not get in the way, the light from the crater of this size would have the following values at the several angles, reckoned below horizontal:

Angle	0°	15°	30°	45°	60°	75°	90°
Light	0	520	1000	1414	1730	1930	2000

These amounts are exhibited graphically in **191**. But as the negative carbon eclipses much of the light, and as its tip throws a little light out sideways, the actual distribution would be more nearly represented by the values:

Angle	0°	15°	30°	45°	60°	75°	90°
Light	220	700	1250	1420	720	0	0

These values are given graphically in **192**. The amount cut off by the negative carbon would be greater if the arc had been shorter. The circle of shadow cast by the negative carbon can be observed on the opal globes of ordinary arc lamps.

Alternating Current Arcs. In alternating current arcs the crater is moved from carbon to carbon many times per second. It is unable to become thoroughly established on either pole; and to obtain the same amount of light more current is needed than for a continuous current arc. The distribution of the light is as shown in **194**. On the other hand, the fixed voltage loss is only about 26 volts, or two-thirds that of the continuous current arc. This is probably due to our measuring with alternating currents the root mean square value, not the maximum value, of the voltage [see page 1290], this value being about two-thirds of the maximum value. The efficiency of an alternating current arc, however, is lower than that of a continuous current one, and all alternating arcs have a distinct hum, the note depending on the frequency of alternation of the supply.

Enclosed Arc Lamps. The open arc as described above is formed in air, which consists, as is well known, of a mixture of nitrogen and oxygen gases. The carbon burns away in the oxygen, and thus carbons have to be constantly renewed. Some years ago, attempts were made to place the arc in a globe entirely closed at the bottom, and nearly closed at the top. It was found that when the arc is first formed it burns in the ordinary way, but as in a few minutes the supply of oxygen becomes exhausted, the gases inside the globe consist largely of nitrogen and carbonic-acid gas, neither of which has any action on carbon.

Under these conditions the arc may be drawn out much longer, the voltage across the arc being increased from 45 to 70 or 80 volts. The carbons burn away much slower, so that the operation of re-carboning is less frequently needed. The efficiency of the arc is not increased [**193**].

Inverted Arcs. For lighting drawing-offices, picture-galleries, and certain classes of workshops, inverted arc lamps are often employed. In these lamps the positive carbons are placed at the bottom, with the result that the greater part of the light is directed upward either to the ceiling or to a large whitened board suspended over the lamp. The lamp is placed inside a metal bowl, which reflects more of the light upward and hides the lamp from the direct line of vision. Thus the reflected light from the ceiling or whitened board is without sharply defined shadows. In fact, it is a close approximation to diffused daylight.

The Magnetite Arc Lamp. It is well to note that successful arc lamps can be made to use other electrodes than carbon. Such lamps are not common in this country, but in the United States and Canada over 60,000 are in use. They are fairly efficient and give a white light. In this lamp the positive electrode consists of a copper block which does not burn away, and the negative of a tube about 8 inches long and $\frac{5}{8}$ inch diameter, which is made of a mixture of black oxide of iron or magnetite and some titanium compounds.

The arc has to be struck, as in the case of the carbon lamp, by making the electrodes touch and then withdrawing them. The arc remains steady when about $1\frac{1}{8}$ inch long, and a shunt wound magnet is arranged to maintain the arc. The light comes exclusively from the flame. The positive electrode has a life of about 6000 to 8000 hours and the negative of about 175 to 200 hours when the lamp is working with a current of 4 amperes. The lamp burns singly on a 100 to 120 volt direct current circuit.

Arc Lamps in Operation. Practical arc lamps must be able to perform the following functions automatically and satisfactorily: (*a*) Bring the carbons together when no current is flowing;

(*b*) Strike the arc—that is, move the carbons a suitable distance apart when the current is switched on; (*c*) Feed forward the carbons as they burn away, so that a constant length of arc is maintained.

There are many ways in which these ends are obtained, but in nearly all of them (*a*) is met by the action of gravity which, when the current is switched off, causes the carbons to drop into contact with each other. The other two requirements depend to a large extent on each other, and consist generally of an electrically controlled mechanical movement. Figs. **198** and **199** show how it is possible to arrange solenoid coils in the lamp circuit so as to obtain series [**198**] or shunt [**199**] control, and **197** indicates a very usual manner of obtaining differential control. Here the cross bar is pivoted at a point intermediate between the two coils, and any increase of strength in the action of the shunt solenoid over that of the series solenoid causes the rod connected to the carbons to be depressed, while any excess of strength of the series coil over the shunt coil raises the carbons.

With such an arrangement, when the current is switched on to the lamp with the carbons touching, there is a heavy series current, but practically no shunt current. The series solenoid rod is drawn up into the coil, and the carbons are separated forming the arc. The resistance of the arc causes the shunt solenoid to become excited, and at last it becomes stronger than the series solenoid, which has been becoming gradually weaker, until at last the shunt solenoid rod is drawn into its coil and the carbons are brought nearer together, thus weakening the strength of the shunt solenoid and strengthening the series one. A balance is maintained which in a good lamp keeps the arc steady.

Methods of Moving the Carbons. There are two general ways of mechanically moving the carbons—one illustrated in **196** shows what is termed a clutch. This is the form used in the Westinghouse Company's open type arc lamp, as illustrated in **201**, which shows diagrammatically the different parts of the lamp. Another favourite system is to secure a brake cord to the lever cross-arm, which is placed above the solenoid coils, and to pass this cord round a brake-wheel. This brake-wheel is pivoted at the end of a lever, and is so arranged that when the band cord is tightened by the action of the series coil the top carbon is raised; and when the band is loosened by the increased strength of the shunt coil the brake is released, and the top carbon is allowed to fall a little by gravity. This is the system of control adopted in the well-known Crompton "S" type lamp.

Arc Lamp Circuits. Arc lamps are run on the series, or the parallel, or the series-parallel system of supply. The windings on the coils have to be modified to suit the various conditions, and in the case of lamps run in series on a high voltage circuit it is necessary to include in each lamp circuit an automatic switch and resistance (capable of absorbing the same amount of energy as the lamp), so that any one lamp failing to act will not interfere with the satisfactory burning of the rest on that circuit.

Flame Arc Lamps. It has long been known that, by adding various chemical materials to the ordinary carbon rods, a great change can be made in the appearance of the arc. Instead of the flame being a dull blue it may become intensely luminous, while the light from the crater will be considerably decreased. A mixture of calcium and sodium fluoride gives a very pleasantly tinted light. The colour can be controlled, of course, by altering the carbon impregnating material.

To get a good flame arc lamp the design has to be considerably modified from the ordinary pattern. Fig. **195** shows the general arrangement of the Westinghouse Company's flame arc lamp, and illustrates the general design of other types. The carbons are tilted to one another at an angle of about 30° [**200**], touching each other at the lower end inside an arched cup, which consists of an inverted bowl made of infusible material. This is often termed the "economiser" bowl. An electromagnet just over this economiser bowl maintains, during the whole time the lamp is alight, a strong magnetic field, which repels the arc outward from the bowl and greatly increases its efficiency. In this lamp the control is effected first by causing the carbons to touch and so strike the arc and afterwards to maintain the proper length of arc by the horizontal, not vertical, movement of the carbons. In this case this is effected by means of a brake-wheel acting through a crank, the movements of the brake-wheel being controlled by series and shunt solenoids as before. In **195** is shown also the substitutional resistance for use when the lamp is used as one of a series.

Another type of flame arc lamp should be mentioned, namely, the Blondel pattern. In this the carbons are vertical. The negative carbon is at the top, and consists of a plain carbon rod. The positive, which is larger than the negative, consists of a carbon shell packed with a mixture of carbon powder with a number of compounds which affect the arc. The arc is somewhat longer than the ordinary arc, and has no crater to direct downward the light, which comes almost entirely from the arc itself.

For comparing the efficiencies of the various lamps discussed, the following table, giving representative average figures, is added.

SILVANUS P. THOMPSON

TYPE OF LAMP	Watts per Candle	Candles per Watt	Candles per h.p.
Carbon glow lamp	3·3	0·3	220
Tantalum lamp	2·0	0·5	370
Nernst lamp	1·5	0·67	500
Osmium lamp	1·5	0·67	500
Ordinary arc lamp	0·67	1·5	1100
Mercury vapour lamp	0·6	1·7	1250
Magnetite lamp	0·25	4·0	2960
Flame arc lamp	0·17	5·8	4300

Tartini Notes. Graces. Trills. Solo and Double Shakes. Vibrato. Harmonics. Pizzicato Effects.

ADVANCED VIOLIN PRACTICE

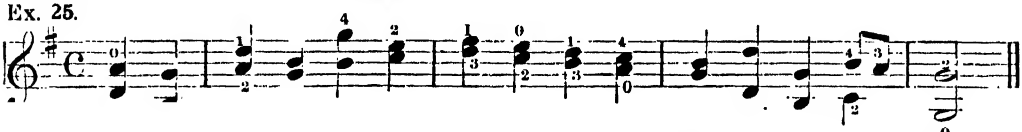
By this time the drudgery of practice should have disappeared. The player will now seek to extend his time of study, being stimulated by the delightful delirium he experiences as progress is made. This pleasure, however, will depart if he does not continue his self-discipline and adhere to his plan of regular and methodical practice. The fact that, whenever a brilliant violinist appears, he, or she, is proclaimed the disciple of some great teacher need be no discouragement. Whoever excels on the violin is indebted more to himself than to the supervisor of his studies. The most expensive master can only point out the right way. He cannot infuse a divine talent into a dull pupil. When there are so many excellent "methods," the danger is that the student, intent on treading too much in the well-worn footsteps of others, may neglect and lose the ability to analyse his own weaknesses and remedy them by compiling—after studying the course on Theory—his own exercises, as many great fiddlers have done in their youth.

In double stopping the student should endeavour, by bestowing great care on the fingering, to get the intervals well in tune. The bow movements in octave passages, and so forth, are effected solely by the wrist, which is helped by slightly raising or lowering the elbow. Listen attentively to each combination of sound. Many violinists who play single notes well in tune are not so successful in double stopping. When they first began this department of study they did not take the precaution to compel their fingers to press the strings at the right points. They failed to realise that the chief difficulty, as well as the chief charm, of double stopping is correct intonation. Thus they contracted a bad habit of making false notes, and lost their perception of the dissonance. This addiction, having taken root after constant repetition, is almost impossible to cure. It therefore repays the student to be very careful at the beginning.

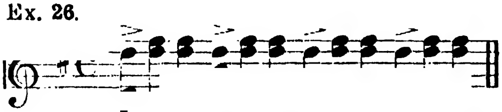
Tartini Tones. In a good violin, when two notes are played in tune together, those sounds are supplemented by another given from the body of the instrument itself. It is deeper than the notes bowed, and resembles the "hum-tone" of a bell which accompanies the "strike-tone." Such resultant harmonics in the violin are known as the *Tartini* tones, so named after the great violinist who first drew attention to them. If this third sound is not audible, it is an indication to the student that his stopping is wrong. Therefore, in practising double stopping, do not listen to the top note only; give more attention to the lower sound. The outline, or melody note, is more capable of taking care of itself. Presumably it is the ambition of the student to prepare himself to play later on some of the most beautiful violin music with instrumental accompaniment. In such compositions he will find double stopping used mainly in cadenzas or flourishes. Meanwhile, the other instruments have a pause of silence. If his intonation is good, his skill will be displayed to advantage; if bad, there will be no kettledrum to hide his defects. The ear of the player can not, therefore, be too scrupulous when learning double stopping. If out of tune, an audience will immediately detect the error, especially in octaves. Playing major and minor scales in thirds is an excellent training in order to get the intervals clearly in succession without using the open strings. The chief trouble is to put the second and fourth fingers into their correct positions, according as the intervals are major or minor. It is of more use to learn to play one scale correctly in double-stopped thirds than to be able to stop all the other scales indifferently.

With a little thought, many helpful exercises [see Ex. 25], to give variety to practice, may be made by the student himself. Ex. 26 is another useful exercise, quoted from Spohr. The student should by this time be ready to attack the graces, or embellishments. Of these the chief are the *shake*, or *trill*, the *turn*, *mordent*, *appoggiatura*, etc. When "plain," the shake is produced by a simple alternation of two single or double notes executed rapidly. This is easy to do badly, but very difficult to do well. What is called by the Italians a *catena*, or chain, is a succession of shakes. Think of a long trill of a singing bird on successive notes. Try to imitate its clear and even effect. Begin slowly, and increase the speed gradually. When the fingers tire, leave off, and begin again later. When an appoggiatura precedes the note to be trilled, and it ends with a turn, the shake is called "prepared." In the upper positions of the fiddle, where the notes come very closely together,

Ex. 25.



Ex. 26.



the student should be careful not to make the sound too sharp.

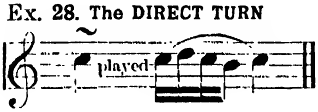
Trill Practice. Trill practice strengthens the fingers. It makes their lowest joints responsive, and gives to them the independence necessary for good violin playing. Great violinists know this; their trill exercise never ends.

Such finger drill can be done without a violin. Place the left thumb against the tip of the first finger, then strike the tip of the second and third, or third and fourth fingers against the palm of the hand. Make the tips strike as far down towards the wrist as possible. Regulate each stroke by the ticking of a clock, or, if in a railway carriage, by the motions of the vehicle. Make the strokes forcibly. Keep the unemployed fingers rigid. As the finger muscles get stronger and more independent, increase the number of strokes to each tick, or the sound by which the practice is regulated. To increase the power of the troublesome little finger, put together the tips of the thumb, first, second, and third fingers. Then make the fourth finger wag backwards and forwards as far as it will go. The motions should be done with regularity and increased velocity day by day.

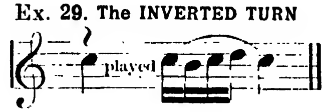
These drills are useful for acquiring that finger-freedom which is indispensable in making a good shake. But such exercises must not be done erratically. After practising at odd moments for a week away from the violin, try the shake on the instrument itself. Record the velocity attained; then continue this independent shake practice. Test the progress made

Ex. 27. THE SHAKE

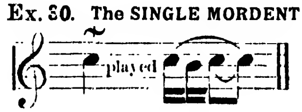
Ex. 28. The DIRECT TURN



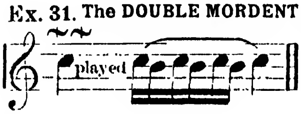
Ex. 29. The INVERTED TURN



Ex. 30. The SINGLE MORDENT



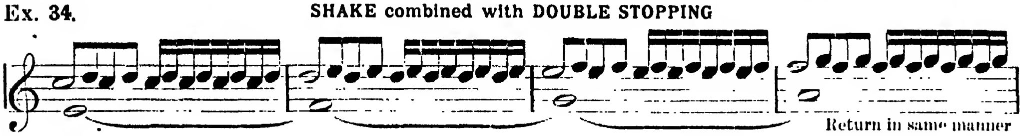
Ex. 31. The DOUBLE MORDENT



Ex. 32. APPOGGIATURA

Ex. 33. ACCIACCATURA

Ex. 34. SHAKE combined with DOUBLE STOPPING



Ex. 35.

at the end of the second week, and so on. The beats in every shake must be equal. Each finger should be raised high, and descend on the string like a little hammer; but the fingers must go down freely. In trills by semitones there should be no rubbing of one digit against its neighbour. It is useless for the student to think that he can learn the shake in a day. Unnatural force should not be used, and over-exertion must be avoided. There is no better practice than to convert each scale into a chain of shakes. [See Ex. 27.]

Solo Shakes. Never use the first finger during practice in a single shake. Pay particular attention to exercising the little finger. In a solo the shake should always be given its full value in time. To render it as brilliant as possible good players sometimes begin a shake half a beat before the time indicated in the music. The student should devote at least a quarter of an hour every day to playing one or more scales up and down the fingerboard with the slow shake at first, increasing the speed gradually. This may appear wearisome unless the self-instructor remembers Samuel Butler's words that "Drudgery and knowledge are of kin." The latter cannot be gained without paying its price, and this is the surest way of obtaining brilliancy and power in fiddle playing. If knowledge is worth having, aspire to get it completely. Do not be retarded by wasting time over alluring and unprofitable tunes. Such are to be found in many violin methods. These pills, to help the learner, are often so highly sugared that the object in swallowing them is misunderstood, although that should be the first consideration. The learner who cultivates the ability to write out his own exercises can practise the shake in a different way each day.

Turns. Having conquered the shake with single notes, the smaller ornaments will be found easy. The *direct turn* consists of three or four little notes preceding or following a chief note. These are played by the same bow which takes the chief note. [See Ex. 28.]

If the turn is *inverted*, it is marked as shown in Ex. 29.

A *single mordent* is a sharp alternation of the note to be played with the semitone above. The word comes from the French "mordre"—to bite. [Ex. 30.]

When two such signs occur over a note two bites occur before the note is emphasised, the ornament then being called a *double mordent*. [Ex. 31.]

The *appoggiatura* is a little grace-note, either long or short, literally "leaning," or resting against a full-sized note. It does not interfere with the time of the music, the two notes being executed with the same bow in the space allotted for the second. [Ex. 32.]

Lastly, the *acciaccatura* (or "short appoggiatura"), meaning to crush, is a little note with a stroke across its tail, preceding a full-sized note. The former is fingered so quickly that it almost appears to tumble into its neighbour. [Ex. 33.]

shake must move with the greatest rapidity and regularity; in the second place, the notes of the accompanying part have to enter as precisely as they would do if attention were concentrated on them alone. Ex. 36 illustrates what is meant.

Vibrato. If Stradivarius, before making a fiddle, had to wait five or six years while the wood of the belly was being dried naturally in the air, protected from sun and rain, it is only fair that the player on such an instrument, who is desirous to excel, should have to exercise his patience for a considerable period. Although unsuccessful at first in controlling the finger sufficiently to master the foregoing exercises, they will appear easy to the student if he goes back now to some of his earlier tasks. To each note of a simple exercise the learner should strive to impart a tremulous or impassioned quality of tone. It is the accomplished violinist who can render the simplest tune most beautifully.

The effect known as the *vibrato* is caused by making each finger in succession throb on the string by increasing and lessening the pressure of the finger-tip. The motion which alters the stopping should be very slight, so as not to interfere with the purity of the tone. Practise slowly and steadily at first. Devote ten minutes to this

Ex. 36. *Larghetto.* ♪= 80. SPOHR.

Ex. 37. CHANGING THE FINGER

The Double Shake. These minor embellishments lead us to the consideration of that extremely difficult ornament the *double shake*. As a preliminary exercise, the pupil is advised to return to the double stopping in sixths, and make a single trill alternately on the top and bottom notes while keeping the bow on both strings. [Ex. 34.]

Now practise making chain shakes with two notes together in thirds, and see that they are in tune. If not, they will be offensive. Begin slowly, listening to make sure of the intonation. Make the beats equal, and increase the speed gradually. On the lower strings shakes are not taken so quickly as on the high ones, owing to the slower vibration. To be effective the shake must be executed literally with "grace." It should be interpolated in a melody with lightness without disturbing the time. Double trills which employ open strings have no turn at the end, We give a useful exercise, which should be continued for two octaves, up and down, and transposed into other keys. [Ex. 35.]

The most difficult of all shakes on the violin is that which necessitates the playing of an accompaniment at the same time, so that the effect is as of two performers instead of one. In the first place, the fingers which execute the

study every day till the vibrato can be produced easily. Give special attention to the weak third and fourth fingers. A long, sustained note may be rendered very beautiful by beginning with the vibrato, slowly and gradually increasing its speed. In old music this effect is sometimes indicated by dots, thus . . . . . Nowadays it is left to the discretion of the player.

It may be noticed that the vibrato is used in four distinct ways. First, it is done quickly, for giving a strong accent to a note. Secondly, it is used for sustaining slow notes in an emotional manner. Thirdly, the vibrato is begun slowly and then quickened, so as to make a crescendo on a long note. Lastly, it is begun quickly, and the throbbing is retarded to make an effective diminuendo.

Tempo Rubato. A refinement of effect in the ingratiating use of the vibrato is a temporary acceleration, or retardation, of the time. This is termed *tempo rubato* (or "robbed time"), when some notes are deprived and others given more than their share of the strict time indicated. But these liberties, although occasionally allowable in solo playing, should be avoided by the student who is preparing to take his place in an orchestra.

Changing the finger on the same note during the same bow is another device for imitating the

human voice. Singers know that, when two syllables of a word spelt differently are sung on the same note with the same breath, the expression of the second syllable is slightly different to the first, the reason being that the vocal cords are employed differently for their enunciation. Almost an identical effect is elicited from a violin string when the second of two notes linked together is stopped by a different finger. However equal the strength of the fingers may be, there is a subtle change in the tone.

The student should now turn to Ex. 37.

In the first bar the second finger is drawn back to C in the first position, so that the fourth finger falls down without any gliding sound. This power of inaudibly altering the fingering of one note is important. Success in portamento playing often depends on it. While the change takes place the bowing must be continued delicately, so that no difference in quality can be detected, especially if, in order to continue the same sound, the string as well as the fingering is changed.

Harmonics. If the violin in finger-changing is capable of closely imitating the singer, it transcends the human voice in another respect. A few accomplished singers with phenomenal range have been able to produce very high vocal notes of a pure and fluty quality, but every violinist can elicit such sounds in greater variety after a little practice. If the fingerboard of the violin is regarded, it will be observed that the free vibration of each string takes place between two fixed points—the nut and the bridge. Now, touch the E string lightly with the first finger half-way between these points. Bow the note softly. The sound heard will be an octave above the pitch of the open string. In quality it is clear and beautiful. In the same manner the string can be made to divide itself into vibrating segments of 3 thirds, 4 fourths, 5 fifths, 6 sixths, and so on. But such sounds are produced most easily from the G string, because it is the deepest in pitch. They are known as *Harmonics*. It was Paganini who first astonished the world by his marvellous employment of harmonics. His rivals regarded the innovation as "claptrap." To play harmonics with facility, the finer the points of the fingers are the better. Thick, stumpy fingers are not well adapted to such work.

Natural Harmonics. In a full-sized violin, half the free length of the E string will be found about 6 in. from the bridge. After touching this point lightly with the first finger, and getting the octave E on the first string, with the fourth finger find that point which measures off one-third, approximately 4 in., from the bridge. Bow lightly. The resultant sound will be B, a fifth above the harmonic E. Measure off with the third finger that point between the centre and third segment, indicating one of the quarters of the whole, or about 3 in. from the bridge, and find that note which gives the double octave of the open note.

But the finger can be placed lower down the finger-board so that it rests over a corresponding lower third—8 in. from the bridge—or second fourth division—9 in.—of the string. The harmonic obtained will be like that at the upper third or upper fourth division, but less clear. By dividing the string into five parts, four similar harmonics can be produced at any one of the notes. They give the double octave of the third of the open note. This ability to choose either position is useful in fingering. That harmonics can be fingered from either end of a fiddle-string may puzzle the student. He has been known to argue that, if he touches the string higher up or lower down, he lessens the vibrating segment. Quite so, if his finger presses the string firmly. But he does not "stop" a note when producing a harmonic, although, touching lightly at a natural point, the whole string continues to pulsate. What is altered are the divisions, or lengths, of the vibrating segments, when the string is partially damped above certain nodes. This causes the higher "partials" of the strings to assert themselves and sound their clear overtones. [Ex. 38.]

Ex. 38.


Ex. 39.


Artificial Harmonics. The foregoing harmonics obtained from the open strings are termed natural, as all harmonics, of course, must be. But when the first finger forms a new nut by stopping the strings firmly, and a disengaged finger lightly touches a node above, the harmonic

Ex. 40.

Bugle notes

Transpose for Violin

Bugle notes

Transpose for Violin

is called artificial. Place the first finger down firmly on C (first ledger line below staff). Let the fourth finger rest very lightly on the position of F, a perfect fourth above the note stopped. Bow the string softly. Instead of F the sound will be C, two octaves above the C stopped by the first finger, because, above the new nut, the shortened string yields the harmonic natural to it. Keeping the first finger in the same place, stretch the fourth lightly over the point for G above the F. The tone will now be G, an octave and a fifth above the note stopped. Practise both the first and second methods of harmonic production. On the G string, a stronger bow can be used than on the gut strings. Extend

Ex. 41.

Bowed

L.H. Pizz.

the series up the scale by semitones the length of an octave. [Ex. 39.]

Excellent practice can be obtained by transposing Army bugle calls a fifth higher, and imitating them. [Ex. 40.]

Con Sordino. "Sordina," or "Sordino," is the Italian for what we call a violin "mute." The effect, however, is not to render the instrument dumb or silent. It is rather that known in singing as the quality of the "bouche fermée," or shut mouth, when the vocalist closes the teeth and almost the lips. In other words, the violin hums. Its tone is thus diminished when a little extra bridge is fixed over the real bridge of the fiddle, or a penny is inserted between two strings behind the bridge. The quality of sound thus obtained is mysterious and mournful, for which reason the mute is often employed in slow pieces of a pathetic character. When the words "con sordini" or "con muta" occur in the music the mute must be put on. It is taken off when the indication "senza sordino" is reached.

Pizzicato. Pizzicato effects for the left hand are got by plucking one or more strings quickly whilst usually bowing another string. Thus, if all four fingers are stopping the second string in the first position, and the fourth finger twitches the string, the note D, stopped by the third finger, is sounded. If the third finger then twitches the string, C, stopped by the second finger, will sound, or if the second finger twitches, the B, stopped by the first, will be heard. In ascending a scale, the operation is reversed by the stopping fingers being put down instead of taken off. The fourth finger then usually does the plucking, so that the point of contact may be as far away as possible from the place where the sound is checked, the effect being best when the twanging is done by the finger farthest away. [Ex. 41.]

ALGERNON ROSE

Drawing, Slubbing, Spinning, Blending, Carding, Twisting, and Winding Woollen Yarn. Warp Sizing. Yarn Testing.

WORSTED AND WOOLLEN SPINNING

THE operations of worsted spinning introduce no principle with which the reader of these chapters is not already familiar, but the application of these principles requires some explanation. The *top* delivered by the comber is in too thick a ribbon for immediate use upon the spinning-frame, and means have to be taken to convert it into a *roving* suitable, in thickness and in other respects, for the yarn that is to be spun. This delicate work of *drawing* involves the use of from six to nine machines, according to the class of wool; and all of these are essentially alike. In each of them there are two pairs of nip-rollers, and in all cases the delivery rollers travel at a higher surface speed than the feed rollers, so that a pull is exerted upon the material, and the sliver is elongated. The drawing machinery in use is of three types, the commonest being that known as *open* drawing.

Open Drawing. In making the tops ready for drawing, the balls have first to be unwound with as little ruffling of the fibres as possible, and without introducing any degree of twist. The work is done automatically upon the revolving *creel*, a simple stand upon which the balls of top rest upon their sides in the opening formed between a pair of corrugated rollers. The balls are turned round and unwound gently by the rotation of these rollers, and the sliver from five or six balls is led simultaneously into the first machine. This is the *can gill box*, which exactly resembles the gilling machines used in preparing long wools for the comb, except that it is fitted with pins of greater fineness [2]. The rollers of the box draft the five or six slivers down to the same fineness as one original sliver, while the teeth of the gills or fallers hold the fibres straight. The fibres are intermixed by this averaging of the sliver from several balls, and uniformity is promoted both in quality and weight. The can gill box delivers its material into cylindrical cans. The *spindle gill box*, which receives the slivers next, and again averages them by taking in five or six ends and turning out a single end, is fitted with large spindles and with flyers. The flyers rotate, dragging the bobbin round with them, and they insert a little twist, so that the sliver becomes a *slubbing*.

Worsted Slubbing. Once the sliver has been twisted, it becomes impracticable to use gill teeth, and the succeeding drawing boxes have no fallers. The slubbing is supported during drafting simply by carrier rolls, and on leaving each of the next boxes the slubbing is re-wound upon bobbins by flyer-spindles, which form part of the machine. The successive boxes have distinctive names, and each is arranged to take several ends of slubbing and to draft them down to one as fine or finer than any of them originally were. A plant for drawing fine, or botany wool, and for turning out 3000 lb. per week, has

Two double head can gill boxes.
Two 2-spindle gill boxes.
One 4- ,, drawing box.
One 6- ,, weigh box.
One 8- ,, drawing box.
Two 8- ,, finishing boxes.
Two 24- ,, second-finishing boxes.
Three 32- ,, dandy reducing boxes.
Ten 32- ,, dandy roving boxes.

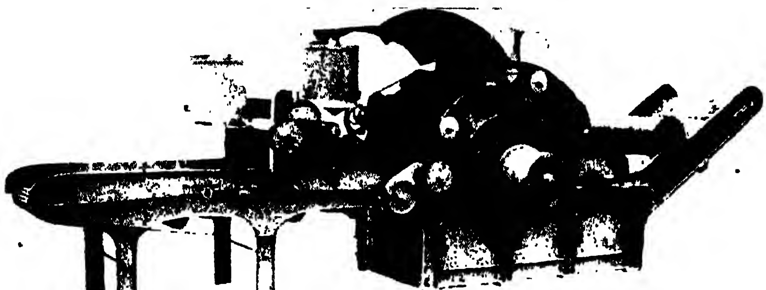
Tops enter the drawing department at a known average weight, usually stated in ounces per 10 yards, and the aim is to produce roving of a fixed weight, weighed in drams per 40 yards. At the *weigh box* a check is imposed to test the weight of the slubbing that is being made. The box is fitted with a knock-off motion, so arranged that the machine stops when a definite length of slubbing has been wound upon the bobbins. The empty bobbins are made of one weight; and when all contain the same length of slubbing it is easy to pair together those which are too heavy with those which are light, and thus to rectify inequalities which would otherwise show in the yarn.

Cone Drawing. The cone system of drawing employs the same number and kinds of machines as are used for open drawing, but each of the boxes has an extra feature. We have seen that in open drawing the bobbin upon which the slubbing is wound is not positively driven, but is dragged round by the thread and the flyer. The arrangement is open to objection, for a bobbin nearly full weighs more than one nearly empty, and consequently exerts more drag. Then the diameter of the bobbin increases with the adding of layer after layer of material, so that the relation of speed between the flyer and the bobbin is changed.

These theoretical deficiencies, although not of much account in spinning strong wools, make their influence felt in the case of fine yarns, and an arrangement of cones and of differential gearing is used to remove them. The bobbin is driven at variable speeds, corresponding with the changes in the diameter made by the winding on of fresh material; and the lifter-rail, which effects the placing of the material upon the bobbin, is worked at fluctuating speed to build up the slubbing in a regular spiral.

French Drawing. The *French system* of drawing, which is relatively little used in this country, produces a different type of yarn. Its distinctive feature is that the whole drawing is done in about nine operations, without putting

twist into the sliver. The tops are mixed together at can gill boxes and are passed into drawing boxes, where they are drafted by roller action. Intermediate between the drafting rollers are simple supporting rolls and a roller called the *porcupine*, because of the pins which are set at a tangent upon its circumference. The porcupine revolves, and the fibres are drawn through its teeth and are thereby held straight. On leaving the delivery rollers the sliver passes between apron belts made of a soft leather, which carry the sliver along, and at the same time give it a rubbing from side to side. The system is valuable for obtaining a bulky yarn from short and irregular staples.



1. THE FEARNOUGHT CARDER
From a photograph by courtesy of Messrs. Platt Bro

Draft and Ratch. We have seen that the amount of draft is determined by the relative speeds of two sets of rollers. The setting of these speeds is one of the most important incidents of the process of making worsted yarn. If the rollers are so adjusted that for every one yard fed into them two yards are delivered, the draft is said to be two. The amount by which any given top may safely be drafted at one operation can only be decided by consideration of the length and uniformity of the fibres. All tops have to be elongated a great deal in order to produce an eligible roving, and botany tops intended to be spun to 60s yarn may need to be drawn from an initial length of 160 yards per pound to nearly 7000 yards per pound before being placed upon the frame. The feat is practicable by proceeding gradually. Drafting a sliver 6 in one direction and in the next box 6 in the opposite direction, we make 36 yards out of one yard in two operations, and, by giving a draft of 6 again, make 216 yards in three operations. Repeated nine times, even upon a diminishing scale, high figures are soon reached.

Drafting has to be done cautiously if the sliver is not to be *twitty* or lumpy. The doubling processes by which slivers are averaged together is the great safeguard against a lumpy result, and slubbing for making fine yarn often receives twenty to thirty of these doublings in its course from the comb to the frame. The draft requires skilled judgment, and not less does the *ratch*, or reach, which is the distance between the pairs of drafting rollers. This distance is adjustable, and has to be made to fit in as closely as may be with the average length of the fibres, so that the longest ones shall not be unduly broken and the shortest ones not escape the pulling that is necessary to adjust their proper place in the slubbing.

Worsted Frames. Four types of machine are used in spinning worsted rovings into yarn, and each of them has already had some mention [see page 1555]. Flyer cap and ring frames are the ones chiefly employed, but there are also worsted mules, although not many are at work in England. The machines all accomplish the further drafting needed to reduce the roving to the required count of yarn, and all of them are fitted with drafting rollers for the purpose.

The flyer frame is used for the stronger wools and for the thicker counts; the cap frame for medium and fine wools, and the ring frame principally for the finest qualities. The mule enables a given roving to be spun to a higher count than is possible upon other machines, but it occupies more room and costs more in labour. Mule-spun worsted is different from the yarns from the throstle frames, being more spongy—a characteristic that is not always wanted. A combination of dry-combing, French-drawing, and mule-spinning gives a maximum of fulness and sponginess to worsted yarn. Oil combing, with open or cone drawing, and flyer or cap spinning are preferred when a strong yarn with its fibres closely laid together is required. Flyer frames cannot be run faster than about 2500 revolutions a minute, because of the vibration at high speeds, but their yarn is smooth. The cap frame is capable of 7000 revolutions, but in revolving round the cap at high speed the thread meets aerial friction, and a rough yarn results if the fibres are long or stiff. It is, therefore, not always advantageous to run cap spindles at the highest speed.

Self-Doffers. The most notable improvements that have been put upon the worsted spinning frames are the automatic *doffing motions*. When the spinning bobbins have been filled it is necessary to replace them by others, and the work of doffing the full bobbins and setting empty ones in their places has to be done by children, many of them half-timers. The process accounts for a material loss of time, as the machine is at a standstill while the hundred or two bobbins are being changed. Self-doffing arrangements for changing the whole of the bobbins upon a frame have been brought into use both for flyer and cap frames, and have been proposed for ring frames, where, however, they are less advantageous, as these machines can be doffed quickly. In the case of the flyer frames the improvement has involved some modifications of the spindles in a direction enabling them to be run at higher speeds, so that there is a twofold gain in productivity. Doffing, which occupies three minutes on an ordinary machine, can be done in one-third of the time by the mechanism on the flyer frame. The operation of a handle starts a series of movements, in course of which the full bobbins are caused to slide from their spindles on to a series of pegs, and the spindles are charged with new empties.

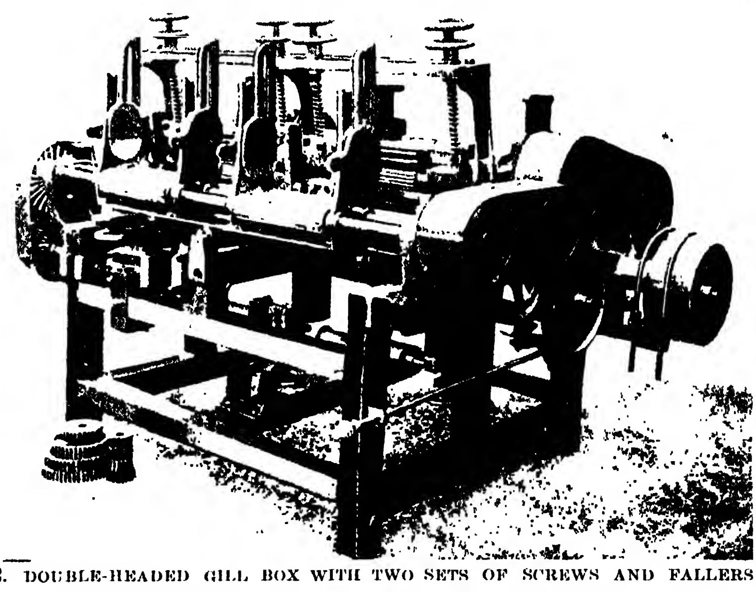
Twisting Frames. Yarn-doubling or the manufacture of twofold thread, which in the case of cotton is a separate trade, is carried on in the worsted industry by the spinner. The doubling or *twisting frames* in use embody the same features as

the spinning frames, with the difference that there are no drafting rollers. Ring doubling is more largely employed in the worsted trade than ring spinning, and both flyer and cap principles are favoured—the flyer for the perfection with which protruding hairs are laid, and the cap frame for the large production that is rendered possible.

Woollen Spinning. We have seen that there are certain broad distinctions between worsted and woollen spinning. Worsted spinning is chiefly done by firms of spinners who neither comb nor weave, whereas woollen spinning is almost always carried out in conjunction with carding and weaving. We have also seen that the woollen manufacturer uses principally the wools that are too short for the combing process, and that his yarns are the opposite of worsted, and have their fibres arranged in an indiscriminate fashion.

It has been stated that, in addition to the naturally short wools, woollen manufacturers are able to use *noils* from the combings, and, in making cheap goods, woollen shoddy recovered from rags and clippings of cloth. They can also use the mill wastes made in working worsted, such as *laps*, or broken lengths of top; *slubbing waste*, formed in small quantities in the drawing process; *roving waste* from the roving machine or spinning frame, and *roller waste* and *fly* from the spinning machine. These are *soft wastes*, requiring little treatment in order to open out their fibres sufficiently for re-working, but use is also made of the *hard wastes*, such as tangled yarn.

Opening Machines. Hard waste has to be converted into soft waste before its fibre can be re-worked, and this is done ordinarily upon a kind of carding engine known as the *Garnett machine*. The cylinder and rollers are not covered with the bent wire pins used as ordinary card-clothing, but with steel saw-teeth, which exert a more drastic action and convert the mass of thread into loose fibre. The *willey*, or willow, which is used both to loosen matted wool fibres and also to mix together materials of different sorts, is an enclosed machine fitted with strong, hooked teeth. It contains a swift, or large cylinder, with three small worker-cylinders revolving upon its circumference. Below the large cylinder is a grate for the reception of dust, and by means of an air-current this dirt is continuously carried away. The amount of opening treatment required before carding is very much a matter of the condition of the particular class of material. Some materials require to be passed through the *fearnought*, which is a simple carding machine furnished with coarse teeth and with a suction apparatus for dust removal, and is capable of treating some five packs (1200 lb.) of wool per day [1].



2. DOUBLE-HEADED GILL BOX WITH TWO SETS OF SCREWS AND FALLERS FOR THE WORSTED TRADE. (Messrs. Taylor Wordsworth & Co., Leeds)

Woollen Blending. There is no hard and fast procedure in woollen spinning. In some circumstances the wool is not even scoured before manufacture, although it is generally scoured upon such machines as are used in washing for the woolcomb, and it is sometimes carbonised as well. *Carbonising*—meaning the reduction of vegetable impurities to dry powder by a saturation in acid, followed by over-drying—is resorted to in the case of *burry* wools.

The materials necessary to make a yarn of a given price and quality have often to be blended, an operation that is done by building up a stack of the several kinds of wool in even layers, one upon the top of the other. Each layer is oiled, and the further intermixture of the several sorts or colours of material is effected upon the willey and the carding machines.

Woollen Carding. Carding, and the opening operations which go with it, is, on the whole, the most critical work of the woollen mill, and it is in this department that money is made or lost. Improperly carded material cannot give good yarn; and the task of the carding engineer is to produce good sliver without loss of weight and in the maximum quantity daily.

There are three machines in a complete set of woollen cards, and they are alike in all essentials except the fineness of their card-clothing. The first is the *scribbler*, generally carrying two 50-inch swifts, each with its complement of *worker*, *stripper*, fancy and *doffer* rollers, and made in widths ranging up to 72 inches. The second is the *intermediate*, with a single swift, and the third is the *carder and condenser*. The machines may be either automatically or manually fed; and, as it is of great importance that the whole set should work at the same speed, there is a growing practice of driving the three cards by means of a continuous chain. The tendency of the card teeth is to straighten the fibres; and as parallelism is not desired it is necessary to correct this effect. The web formed on the scribbler is accordingly fed into the intermediate machine diagonally, so that the fibres enter

sidewise and not lengthwise. The direction is changed again upon entering the carder, and on leaving this machine the flat web of wool is divided into slivers by the action of the condenser. The division is made by rings or, in the Belgian system, by leather tapes, and the slivers are rubbed into a rounder and firmer state as they pass between travelling leather aprons.

The Woollen Mule. The carded sliver wound upon the large condenser bobbins is placed upon the creel of the woollen mule, a machine differing from the worsted mule principally in carrying no drafting rollers, and closely resembling the cotton mule [page 1695]. The machine has only the one pair of rollers that are needed to hold the sliver firm. The drafting or elongation of the sliver is effected by the outward run of the travelling mule carriage, and the yarn is twisted while it is being pulled. The twist acts first upon those parts of the thread that are thinnest, and accordingly weakest, and thus tends to prevent the breakage of ends.

Mules are made of different lengths to carry spindles up to 600 in number. The daily production is less than that from the continuous frames, but a very full and elastic yarn is produced; and little progress has been made with any alternative machinery for making woollen yarns like those spun upon the mule.

Twisting and Winding. Woollen yarn is less frequently required in a twofold state than is worsted, but it is doubled either upon the *twiner*, a form of mule, or upon the ring-twisting frame, which machine gives a larger production. Both woollen and worsted yarns are re-wound, and largely upon the split drum winder [page 1827]. The yarns were formerly sold chiefly in hanks, or upon the bobbins or cops upon which they had been spun, but they are now delivered largely in warp ready beamed for the loom, on tubes for the shuttle, or in cross-wound cones or cheeses suitable for the knitting machine.

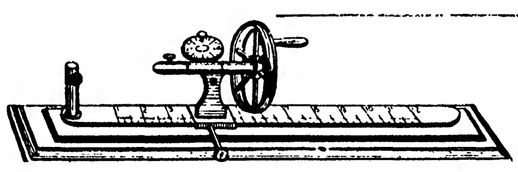
Warp Sizing. Most woollen and a few worsted warps require *sizing* before they can be woven, but, as sizing of wool goods is not undertaken with a view to increasing the weight, the operation is less difficult than in the case of heavy-sized cottons. The treatment is intended only to strengthen the threads, fasten down protruding fibre, and prevent yarns from being roughened in weaving.

Starches are used, and sometimes with objectionable results, made visible by the appearance of white spots upon the surface of a dress fabric after a wetting with rain; and there are proprietary chemical compounds that can be used without risk of ill effects.

The commission warp-sizers who work for the dress goods trade employ the *slasher* machine as well as certain other types. A French machine which has been largely adopted for wool warps differs from the sizing machinery that has been already described in connection with the cotton industry in having a vertical drying chamber. The warp is led, after passing through the size trough, to the top of the chamber and down again in an atmosphere heated by steam. Drying is assisted by the action of fans which blow hot air through the threads.

Warping Mills. The methods of warping worsted are not significantly different from those in vogue in the cotton trade. The beam warping machine is used increasingly, and the old upright warping mill has been replaced by the *Scotch warping mill*. The mill or wheel upon which the warp threads are wound is from ten to thirty feet in circumference, and its axis is horizontal—a position which is especially convenient in warping coloured threads to form a regular pattern.

Successful worsted spinning requires attention to a great number of small points apart from those arising out of the defects of the raw material. Bent or split pins in the gill fallers, defective leathers upon the drafting rollers, jagged edges upon the cans in which sliver is coiled, worn bearings, excessive or defective lubrication are merely a few of the myriad causes by which yarn may be spoiled. The setting of the speeds and distances, and the adjustment of the drag of bobbin, fall to men who may be either negligent or diligent, although the great majority of worsted overlookers are painstaking men. The carelessness of girls, involving the production of too much waste, adds most seriously to the cost of working, and the defaults of children in removing fluff from the rollers may easily spoil large quantities of yarn. Marked differences between the yarn produced in two mills using the same class of material are to be traced to small causes of these kinds.



3. THE TWIST TESTER

The perfection demanded in worsted yarn intended for weaving fine, plain goods is microscopic; and what is demanded most of all is that the yarn shall be perfectly *level*, which means not thicker in any place than in another. The yarn must not be hairy, and its twist must be regularly distributed throughout. It has to be true in length and weight, and up to the standard in strength. A good idea of the comparative levelness of yarn can be formed by opening out a hank and examining the threads while holding the yarn diagonally and facing away from the light. Strong inequalities of twist in a twofold yarn reveal themselves upon a careful examination of short lengths wound upon a black card.

The average twist can be counted with the aid of a simple apparatus [3]. A length of the yarn is put upon the twist-tester, and is held at one end by jaws and attached to a hand wheel at the other. An engraved scale shows the length of the sample under test, and a dial records the number of revolutions needed to remove the whole of the twist that has been given in doubling the single yarns together. It is less easy to count the turns per inch in single yarn, but appliances are made for the purpose.

Strength of Yarn. Worsted yarns are usually tested for strength by taking a lea of 80 yards and trying the breaking strain of the whole skein, although this does not give the most conclusive evidence of strength. In the official Testing Houses there are machines for trying and recording the tensile strengths of individual lengths. The *Moscrop yarn tester* is arranged to test yarn from six bobbins individually, and automatically to perforate holes in a diagram showing at what tension each successive length was broken. The method gives the strength of individual lengths separately.

J. A. HUNTER

Processes of Change. How the Earth's Crust is Influenced from Below. Volcanoes, Geysers, Earthquakes, and How they are Caused and Studied.

THE EARTH'S INTERNAL FORCES

In the preceding chapters we have dealt entirely with *descriptive geology*. We have considered the constitution of the rocks and minerals which form the crust of the earth. We now come in due order to the consideration of *physical*, or *dynamical, geology*. By this is meant the study of the various natural agencies which have given rise to the state of matters which now obtains on the earth's surface. It investigates the processes of change which are now at work upon the earth, and also helps us to see how, in the far-distant past, they have modified the primeval rocks. We have already seen that the earth's crust, when it first solidified from its original molten condition, must have been composed entirely of igneous, or crystalline, rocks. We know that at the present day the greater part of the surface is covered with soil and stratified rocks, which are very greatly changed from that earliest solid product of the fiery nebula. The business of physical geology is to tell us in what way these changes took place.

Uniformitarianism. The early geologists were in the habit of thinking that this beneficent change from the bare volcanic rocks and the fire-smitten deserts of the early world to the fertile fields which now grow ripe for harvest, and the kindly soil on which man lives and has his being, must have been due to some correspondingly extraordinary change in the order of Nature. They were always ready to evoke the aid of some gigantic cataclysm in order to explain the geological history of the earth. We are wiser nowadays, and find ourselves able to explain all these changes without going beyond the agencies which are still at work, both inside the crust of the earth and on its surface.

It is true that many of these agencies have been accustomed to operate in the past with far greater violence than they ever put forth in the present day. Our modern volcanic eruptions are trifling displays of fireworks when compared with the gigantic outflows of lava which produced many of the igneous rock formations of the earlier world. We know no such earthquakes as those which shattered and rent the crust of the earth while it was still thinly covering the subjacent abyss of liquid fire. Even the action of comparatively gentle agents like winds, rivers, and waterfalls is probably much slower nowadays than it was in the distant ages of the earth's history, as written in the fossiliferous rocks. The glaciers of the Alps and the Himalayas—even the gigantic ice barrier which defends the greater part of the Antarctic continent—are only a faint shadow of the ice-sheet which once clothed almost the whole of Northern Europe. But though these agencies have lessened in degree, they are still the same in kind.

The great doctrine of *uniformitarianism*, which was enforced by Sir Charles Lyell with all the weight of his genius, and is now universally accepted by geologists, teaches us that we need not attempt to explain the history of the earth by introducing any agents which show a marked difference from those which are at work today. Such convulsions of its surface as the earth has known still find their analogues in the processes of Nature, and were at the utmost only an exaggeration of the processes which we can watch in action at the present day.

Processes of Change. We all have a general idea of the *processes of change* which are now at work upon the rocks. We see the wind day after day sweeping up the dust from one part of the dry earth and heaping it up in another. We know that when the rain falls it converts this dust into mud, and often washes it away, leaving the surface of the fields or roads bare sheets of naked rock. The farmer and the gardener tell us how frost pulverises the soil and split up stones and rocks. We cannot take a country walk without seeing how the little streams and rivers are continually washing soil away from one place and depositing it in another.

An inexpensive excursion to Switzerland will familiarise us with the work of glaciers in chiselling out valleys, smoothing rock-surfaces like gigantic planes, and transporting vast boulders from their perches high up among the hills, to perplex travellers in the valleys. Every holiday at the seaside shows how the waves of the ocean are continually battering the shore, breaking down the hardest quartz rock into fine sand, and ever making deeper and deeper inroads upon the most lofty and imposing cliffs.

Internal Influences. We are less familiar with those agencies of change which are within the surface of the earth. In this part of the world, at any rate, we have no acquaintance with volcanic activity; and if an earthquake does come our way, it is so gentle that, as a rule, we only learn of its existence from the newspapers next morning. But we know from the reports of travellers in the tropics that volcanoes are still at work pouring out lava over the surrounding land, that earthquakes are still competent to swallow up whole villages, and open chasms which seriously affect the surrounding strata. It is our business now to study the action of these various agencies as modifying the crust of the earth.

Hypogene and Epigene Agencies. We may divide these agencies into two classes for convenience of study, according as they operate above or beneath the surface of the earth. There is a fairly obvious distinction between the superficial agencies which produce such changes as

we mean when we speak of the weathering of rocks, and those subterranean forces which are the cause of volcanic activity, and give rise to earthquakes or to less perceptible secular movements of the earth. The subterranean agencies are called by geologists *hypogene*, while the superficial are known as *epigene*. Both these agencies, which do so much work upon the earth's crust, owe their existence to the same source of energy, being derived ultimately from the heat of the original nebula out of which the whole solar system has been developed. [See ASTRONOMY.] They may be tabulated as follows.

HYPOGENE	EPIGENE
(*a*) Volcanoes.	(*a*) Atmospheric.
(*b*) Earthquakes.	(*b*) Aqueous.
(*c*) Slow secular movements.	(*c*) Glacial.
(*d*) Chemical action.	(*d*) Organic.

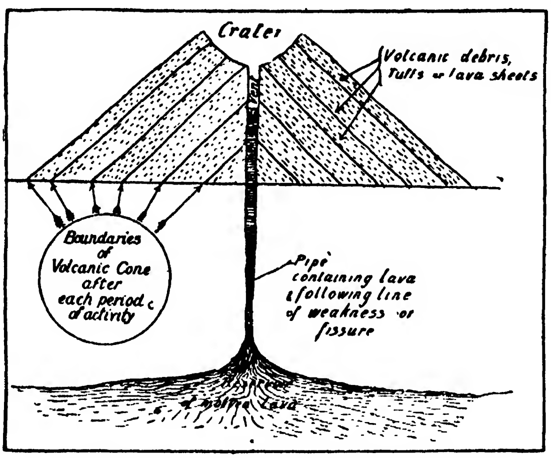
The hypogene agencies, as may be readily seen, are mostly due to the heat still remaining in the interior of the earth. It is no difficult task to trace the association of volcanoes with the central fire, and we shall see later that earthquakes, and the slow secular movements of the earth's crust, are alike due to the fact that the earth has been slowly cooling since it first came into existence.

The epigene agencies owe their powers almost entirely to the heat of the sun, which is itself the residue of the original nebula. They are practically all due to movements of air and water, or to changes of the temperature, or to the action of life; and none of these could exist if it were not for the sun's heat.

Volcanic Action. By a volcano we usually understand a mountain, generally of conical shape, whose summit contains a crater or opening through which hot vapours, hot gases, volcanic bombs, ashes, and streams of molten lava are ejected during its activity. Vesuvius, Etna, Krakatoa, and Mont Pelée present familiar types of such mountains. [See pages 286 and 1699.] All volcanoes, of whatever type, are simply channels of communication between the surface of the earth and the reservoir of molten rock which exists at a varying depth in the interior of the crust. In the past, however, volcanic activity has by no means been always associated with mountains of this kind. When the earth was younger, and the solid crust considerably thinner than it is nowadays, there were vast eruptions which were due to the rending of the crust along huge fissures, often hundreds of miles in extent, from which millions of tons of molten igneous rocks welled out and submerged the surrounding country. The only recorded example of such a *fissure eruption* in modern times is that which took place in Iceland in 1783, but the study of the geological record shows that such phenomena were extremely frequent in earlier ages, and gave rise to vast masses of igneous rock.

A Simple Volcano. It is easy to see why the modern volcano is almost invariably a conical hill or mountain. If we consider what happens at a vent which has thus been opened between the molten interior and the surface of the earth, we shall see that the molten rock, welling up from within the crust and overflowing in all directions from the vent, rapidly solidifies into a roughly circular mass, of which the vent is the centre. When more molten lava is poured forth, it still wells out in the same circular form, and the cone is gradually built up round the vent, which is bored through it as a vertical pipe.

The simplest type of volcano is that of a single cone thus formed around one centre of eruption [**34**]. The summit is usually truncated, and presents a cup-shaped cavity, called the *crater*, into which the central pipe opens. Most existing volcanoes consist of not one but many cones, each of which has at times been a centre of eruption. This considerably complicates the original constitution shown in the diagram [see also coloured plate facing page 1697].



34. DIAGRAM OF A SIMPLE VOLCANO

Volcanic Products. The volcanic vents which connect the surface of the earth with the molten interior emit various kinds of material, which may be classified as gases, water-vapour, lava, and rock fragments or dust. Many of the *gases* emitted by volcanoes have a corrosive or solvent action upon the rocks with which they come in contact. Superheated steam, which is one of the gases most common among volcanic products, has a powerful disintegrating action upon the lava through which it breaks its way. The water which many volcanoes throw out—generally, of course, in a highly heated condition—collects large quantities of volcanic dust, and forms a pasty conglomeration of what is known as mud-lava.

The chief importance of volcanoes, however, as agents of geological change, consists in the *lava* which they emit. Lava is a term generally applied to all the molten rocks which are ejected from the interior of the earth. We have seen in the preceding chapters that a large proportion of the igneous rocks which originally formed the whole of the earth's crust were once volcanic lavas. Lastly, in addition to gases

TERRIBLE FORCES PENNED UP IN THE EARTH

A VIEW OF VESUVIUS SHOWING THE CONE AND LAVA-FIELDS

THE DEVASTATING ERUPTION OF SAKURAJIMA VOLCANO, JAPAN

and molten lavas, solid fragments of rocks are frequently ejected from an active volcano. The larger of these are known as *volcanic bombs* or *blocks*, which are simply pieces broken off from already solidified columns of lava, and hurled out of the vent by the pressure of gas, just as a shell is fired from a cannon.

A great quantity of solid matter is also ejected from volcanoes in the form of *dust* which has been produced by the disruptive effect of gases at a high temperature and under great pressure. They explode, so to speak, as the lava with which they are mingled approaches the surface. This dust is often sent floating up high into the air, and is diffused by the atmospheric currents over a very large area. It has sometimes been known to travel half round the world before subsiding to the earth. The great eruptions at Krakatoa, in 1883, and Mont Pelée, in 1902, are believed to have caused in this way the remarkable sunsets which were seen in England during the following summers.

Volcanic Action Everywhere. There is practically no part of the world, as we now know it, in which traces of volcanic action cannot be found. Once upon a time the earth seems, indeed, to have been split and furrowed in all directions by the activity of the central fires which are now approaching a state of quiescence. Nowadays volcanic activity is limited to a comparatively small number of regions, and extinct volcanoes are considerably commoner than active ones. Arthur's Seat and North Berwick Law, in the Scottish Lowlands, the regions of the Auvergne in Central France, and the volcanic Eifel, beside the valley of the Rhine, offer good examples of volcanoes once active, but which have shown no signs of eruption for thousands of years. There is no essential distinction between extinct volcanoes and dormant volcanoes, as history shows that a volcano which has been extinct so long as human memory records may suddenly break out into a remarkable state of activity. This was the case with Vesuvius just before the destruction of Pompeii. But there can be no doubt that, on the whole, volcanic activity has steadily declined since the beginning of human history, and that a time will come when all our terrestrial volcanoes will be as inert as those of the moon.

Distribution of Volcanoes. The distribution of active volcanoes, of which there are between three and four hundred now in existence, deserves study. They are found in greatest number on the shores of the Pacific Ocean, where more than half of the now active volcanoes are situated. As a rule, they are situated in the neighbourhood of the sea, or of some considerable sheet of water. They are generally arranged along lines of fracture or folding in the earth's crust, as, for instance, in the chain of the Andes. Many volcanoes also arise from the submarine ridges of the ocean basins. and a few, as in Italy and Iceland, are ranged in groups in place of the prevailing distribution in a linear series.

Geologically considered, volcanoes may be said to mark the places of weakness in the earth's crust where some vast fracture has occurred in the rocky mass. The liquid rock of the molten interior, under intolerable pressure, makes its way to the surface through these fractures and along the lines of least resistance. A study of the geological record shows that volcanic action has always been most abundant in certain limited areas which mark these great lines of weakness in the earth's crust. The special geological work of volcanoes and of fissure eruptions has been to bring to the surface the vast masses of igneous rock which in many cases have thus been intruded among the strata of earlier sedimentary rocks, upon which they have had a baking or metamorphic action.

Geysers. In speaking of volcanic action we should mention the curious natural fountains known as *geysers*, so common in Iceland and in the Yellowstone Park. These are, so to speak, water volcanoes, or springs, which rise from an extremely hot region. Their water is periodically ejected in jets or fountains by the pressure of steam formed in the lower portion of the pipe and unable to escape except by this explosive action.

Earthquakes. The study of earthquakes, known as *seismology*, has made a very considerable advance of recent years. This is largely due to the interest that Japan, as a rising nation, has been forced to take in the convulsions which are continually shaking her cities to the ground, and which compel her architects to study the conditions necessary for erecting permanent buildings, in spite of these constantly recurring and inevitable shocks. Earthquakes in our own country, as we know, are scarcely ever violent enough to endanger our buildings; at the worst, a wall may be cracked or a chimney shaken. But in the countries where earthquakes are frequent and considerable in extent they have been known to cause terrible destruction. The city of Caracas was nearly destroyed in half a minute, with 10,000 of its inhabitants. Port Royal, in 1692, and Lisbon, in 1755, were almost entirely wrecked by earthquakes. On December 28th, 1908, at Messina, occurred the most awful earthquake within living memory, by which nearly 200,000 people were killed.

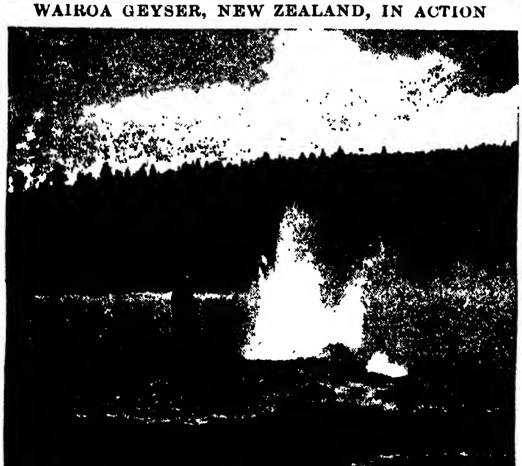
We know now that these gigantic convulsions are merely the temporary exaggerations of tremors which are constantly passing through the surface of the earth. The *seismometer*, an instrument consisting essentially of a carefully balanced pendulum which is sensitive to the slightest motion in the base upon which it is suspended, shows us that the earth is continually and everywhere traversed by rapid and weak tremors, as well as by shocks of longer duration, and often of periodical recurrence. Earthquakes, as a rule, are merely exaggerations of these movements. When the motion of the earth's surface as indicated by such instruments exceeds ½ in. in extent, the result is an earthquake of an extremely dangerous and destructive kind.

GEYSERS IN NEW ZEALAND AND AMERICA

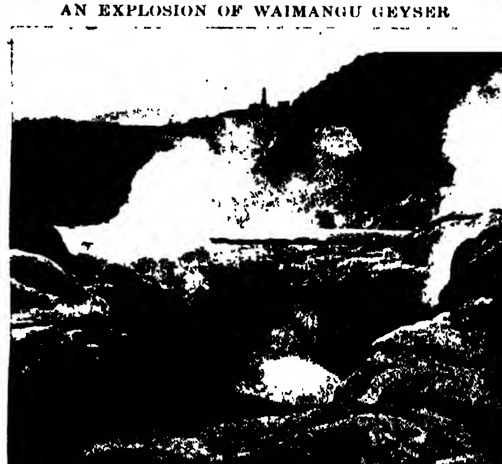
A GENERAL VIEW OVER THE UPPER GEYSER BASIN IN YELLOWSTONE PARK, UNITED STATES

WAIROA GEYSER, NEW ZEALAND, IN ACTION

AN EXPLOSION OF WAIMANGU GEYSER



BLACK WARRIOR GEYSER, YELLOWSTONE PARK



POHUTU GEYSER, NEW ZEALAND

Earthquake Waves. All these tremors are due to waves propagated through the crust of the earth by causes analogous to the explosion of a mine or the fall of a huge stone. The jar which we feel throughout the house when a heavy vehicle passes along the road, or when a stout man jumps out of bed on the upper floor, is precisely similar to what we call an earthquake, though, fortunately, less in degree. These earth-waves travel at definite speeds, which can be measured with considerable accuracy, and which vary according to the substance through which the waves are transmitted. They naturally travel faster through a hard and close-grained rock like granite than through a loose substance like sand.

The direction in which they are travelling at any particular place can be determined by observing the direction in which walls or similar objects are cracked by shock; this happens at right angles to the emerging wave. If, when an earthquake occurs, several observations of this nature have been made in different places, it is possible to make a fairly close approximation to the place at which the earthquake originated beneath the surface by prolonging lines backward from each of these stations, and calculating the point at which they would all meet within the earth. It has thus been observed that earthquakes usually originate within the upper portions of the earth's crust at a depth which is seldom greater than fourteen or fifteen miles.

35. VALPARAISO AFTER THE EARTHQUAKE OF 1906

The Cause of Earthquakes. It is not difficult to see that we must look for the cause of all earthquakes—from the merest tremors insensible to man (which nevertheless leave their traces on the delicate instruments of the seismologist) to the vast cataclysms which wreck whole cities and submerge long coast-lines beneath gigantic ocean waves—in some subterranean shock or displacement. This may occur in various ways; sometimes it may be due to the sudden collapse of the roof of a subterranean cavern. In limestone districts, where the underground water is able to dissolve the substance of the rocks, and thus to leave huge caves, which every now and then become incapable of the task of supporting their roofs, small earthquakes of this nature are not uncommon. A small number of earthquakes, again, are no doubt due to volcanic explosions in the lower regions of the earth's crust. It was once supposed that earthquakes were always closely connected with volcanoes, but this proved to be erroneous; and, as a matter of fact, the most powerful and numerous earthquakes occur outside the limits of volcanic districts.

It is now generally admitted that the recognised cause of most earthquakes is to be found in the sudden yielding of subterranean rocks which are under great strain from the superincumbent strata. It can readily be seen that at a depth of five to fifteen miles beneath the surface, where the majority of great earthquakes originate, the rocks must be in a state of extreme strain. Every mile of the superincumbent strata is probably responsible for a pressure of twenty or thirty tons to the square inch upon those which lie beneath, and it is clearly conceivable that every now and then the most massive rocks must yield or snap under this intolerable pressure. When they do so, a more or less violent set of waves is originated, which radiate outwards in all directions, and when they reach the surface of the earth give rise to all the destructive phenomena which we call by the name of an earthquake. There can be little doubt that these ruptures, or readjustments, are continually going on in a small way, and give birth to the constant tiny tremors which are recorded by seismological instruments; but it is comparatively seldom that they are violent enough to produce seriously destructive effects.

Not infrequently earthquakes take place on the floor of ocean basins, where they generally make themselves known by the propagation of vast ocean waves, which cause serious, and often fatal, inundations when they reach the nearest land. In 1896, nearly 30,000 people were thus drowned on the coast of Japan by an earthquake wave, which was also felt at San Francisco, nearly 5000 miles away. Submarine telegraph cables are not infrequently broken by these submarine earthquakes, and a famous scare of invasion was once raised in Australia by the simultaneous destruction of all the cables, and the consequent isolation of that continent from the rest of the world.

W. E. GARRETT FISHER

Types of Governors. Centrifugal Force in Machine Construction and its Requirements. Different Kinds of Flywheels. Hammers.

GOVERNORS AND FLYWHEELS

It seems a far cry from the devout Galileo watching the swinging of a lamp in the dim religious light of a church at Pisa to the mathematical theory of a governor!

Yet the factors that enter into calculations concerning governors are related to those with which the swinging of a pendulum are concerned. A few simple tests with a leaden ball attached to a fine thread suspended from a hook or nail will reveal one or two important relations between the length of thread and number and time of oscillations. If the arc through which the leaden ball swings be not very great, it will be noticed that with the same length of string the same time is occupied by each oscillation, although the angle through which the pendulum swings may vary. In other words, the oscillations through small arcs are isochronous (Greek *isos* = equal, *chronos* = time).

The Pendulum and the Governor. Careful observation would also show that as the thread is increased in length the time occupied by each swing increases, and that the number of oscillations in a given time decreases. With one thread 9 or 25 times as long as another, the time of each oscillation will be three or five times as long, and the number of oscillations reduced to $\frac{1}{3}$ or $\frac{1}{5}$. That is, in different pendulums, the duration of the oscillations varies as the square root of the length of the pendulum, and the number of oscillations in a given time varies inversely as the square root of the length. Several important relations are shown by the formula $t^2 : \pi^2 :: l : g$, where t is the time in seconds of one oscillation; π, the ratio between the circumference and diameter of a circle $= 3{\cdot}1416$; l, the length of pendulum; g, the acceleration due to gravity, 32·2 feet per second. Thus,

$$t^2 g = \pi^2 l,$$

and therefore time,

$$t = \pi \sqrt{\frac{l}{g}},$$

and acceleration of gravity,

$$g = \frac{\pi^2 l}{t^2}.$$

(This latter formula has been used for determining the value of the acceleration of gravity at different points in the earth's surface.)

The connection between the theory of the pendulum and that of the governor is more clearly seen in considering the action of a simple conical pendulum [167]. The ball G, suspended by the string GH, from the point H, describes a circle as shown by the dotted lines, outlining in its revolution the figure of a cone. Now, the forces which act on G are identical with those acting on the balls of an unloaded Watt governor, if we neglect the weight of the arms and sleeve.

The Operating Forces. These forces are three in number: A, the tension or pull of the string, as shown by the arrow, along GH, this being equivalent to the pull of the arm of a governor [**168**]; W, the weight of the ball acting downwards; F, the centrifugal force tending to move the mass outwards from the centre (see below). Here, then, we have a system of forces in equilibrium to which the triangle of forces may be applied [**168**]. Then, $F : W :: r : h$, r being the radius from the centre of the mass to the axis, and h the height of revolution. Therefore, $F \times h = W \times r$, and since, as stated below, centrifugal force

$$= \frac{W\pi^2 r n^2}{900g},$$

this value of F may be substituted in the equation:

$$\frac{W\pi^2 r n^2}{900g} \times h = W \times r$$

and

$$W\pi^2 r n^2 \times h = W \times r \times 900g.$$

Therefore,

$$h = \frac{W \times r \times 900g}{W\pi^2 r n^2} = \frac{900g}{\pi^2 n^2};$$

and since $900g \div \pi^2$ is a constant, it is clear that the height of revolution, h, does not depend on the weight of the ball or the length of the arm, but on the rate of revolution. As this increases, h must diminish, just as the shortening or lengthening of the rod of an ordinary pendulum affects the number of oscillations in a given time. As h diminishes, owing to the increased speed of the engine and consequent flying outwards of the balls, the sleeve is raised, and this, acting on the links and levers, partially closes the throttle valve, and so reduces the volume of the steam and speed of the engine, as described later.

If the number of revolutions per minute are known, the value of h may be found for this class of governor by the above equation ($\pi^2 = 9{\cdot}8696$; $900g = 28{,}980$). And since $n^2 = \frac{900g}{\pi^2 \times h}$, then the number of revolutions per minute

$$n = \frac{1}{\pi}\sqrt{\frac{900g}{h}}.$$

The Loaded Governor. In order to enable the governor to work at a higher speed and operate the throttle valve with greater delicacy and precision, the governor is loaded by a central weight, and the relations shown by the equations for an unloaded governor then become:

$$h = \frac{900g}{\pi^2 n^2}\left(\frac{W + w}{w}\right),$$

$$n = \frac{1}{\pi}\sqrt{\frac{900g}{h}\cdot\left(\frac{W + w}{w}\right)},$$

in which W is the weight in pounds of the central weight, and w that of each ball. On comparing these equations it is clear that for any particular height of revolution, the speed of revolution is greater in the loaded than in the unloaded type; and that for any particular rate of revolution, the height, h, is less in the loaded form than in the other type. Also, the advantage in speed is represented by the ratio $\sqrt{W + w} : \sqrt{w}$. Friction has also to be considered, but both theoretical and practical demonstration show this to be a negligible quantity as $W + w$ is increased. Loading a governor either by a central weight or a spring thus provides a means of overcoming great frictional resistance.

Centrifugal Force. In considering the forces acting on the balls of a governor, allusion was made to centrifugal force, and, before proceeding further, it will be advisable to consider this force. Really the term centrifugal (Latin *centrum* = the centre, *fugio* = I fly from) is a misnomer bequeathed to us by early philosophers, who concluded that a force existed tending to drive bodies revolving in a circle away from the centre. Otherwise, they argued plausibly, how shall we explain the counterbalancing force necessary to compel a body to revolve in a circle as seen, for example, in the whirling round of a weight attached to a string. Hence, the term *centrifugal* force was used to indicate the tendency of the body to fly from the centre, and *centripetal* force to indicate the pull towards the centre, these forces being necessarily equal and, of course, opposite.

Actually, however, the tendency of such a body is to continue its motion in a straight line—*i.e.*, to obey Newton's first law, "Every body continues in a state of rest or of uniform motion in a straight line, except in so far as it is compelled to change that state by force acting on it." Therefore, at any point in the circle the body W [169] is forced to move in an unnatural path, and tends to move as a tangent to that circle, as at *a–b*, *c–d*, *e–f*. Remembering that the term acceleration may mean a change in *direction* as well as in velocity, the body W thus has an acceleration towards the centre of the circle, its amount being represented by $v^2 \div r$; v = velocity in feet per second, and r = the radius of the circle in feet. The centrifugal force is the product of this acceleration and the mass of the body, and since the latter

$$= \frac{\text{weight of body}}{}$$

then $$F =$$

in which F represents the magnitude of the centrifugal force and W the weight of the body in pounds. As velocity

$$= \frac{2\pi r \times n}{60}$$

($2\pi r$ being the circumference of the circle, and n the number of revolutions per minute), this quantity may be squared and substituted for v^2 in the formula, thereby giving another statement for centrifugal force when the number of revolutions per minute are known.

$$F = \frac{W\pi^2 r n^2}{900g}.$$

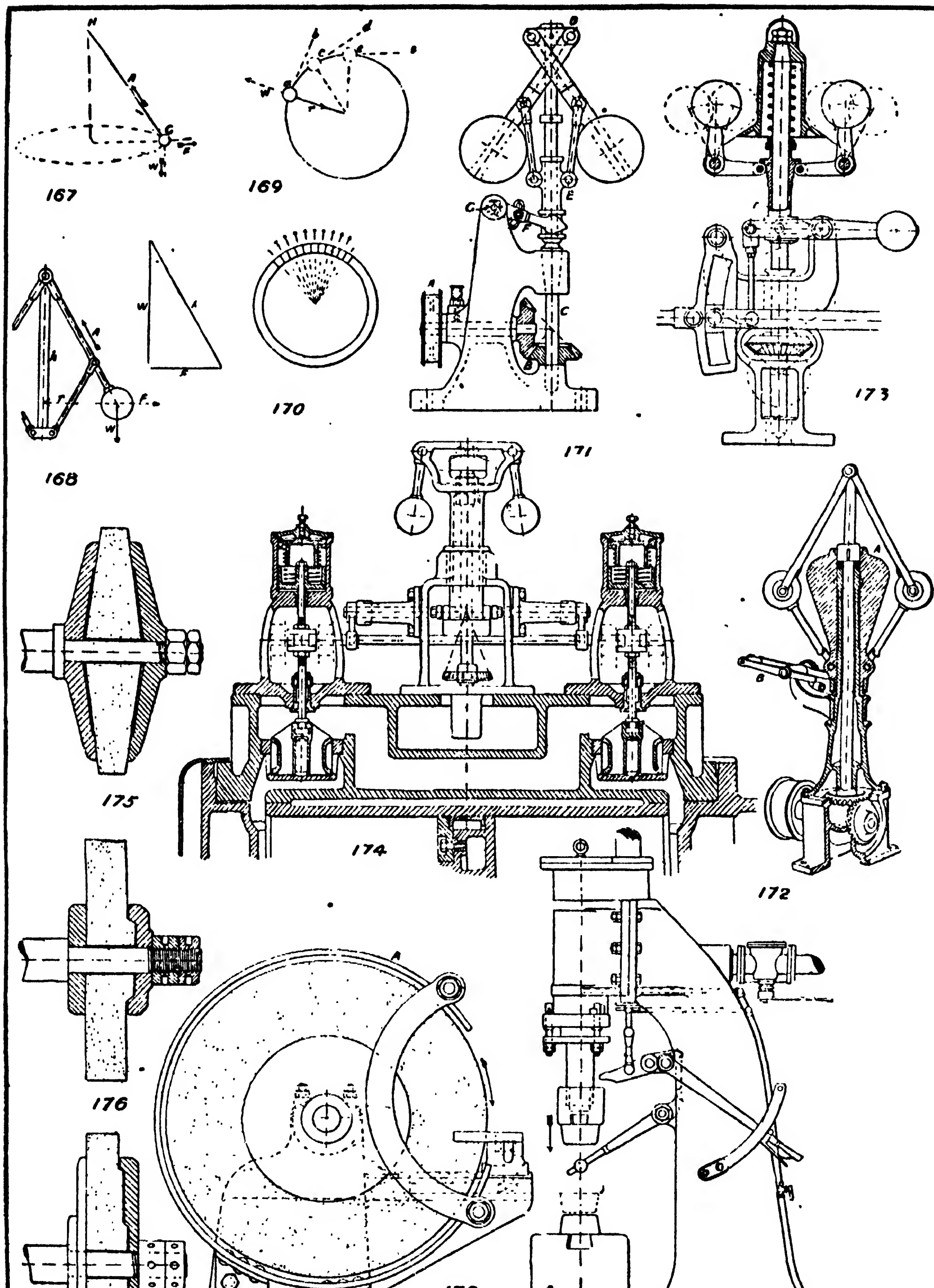
Wherever, in engineering, revolving masses are concerned, these centre forces have to be considered, and if there exist any lack of balance in the revolving parts, the wear on the bearings, and the vibration set up, will cause considerable damage.

Bursting of Flywheels. In the governor (which *regulates* the speed of an engine), centrifugal force is utilised in the opening out of the balls, but in the flywheel (which *steadies* the speed of an engine), and other revolving wheels, centrifugal force produces a tension in the rim sufficient at times to burst the wheel, sometimes causing loss of life. Consider the rim to be divided into a great number of small sections, as in **170**. The centrifugal force for each separate section is then equal to: weight of section $\times v^2 \div rg$. For the whole, the aggregate of all the sections, F = weight of the rim $\times v^2 \div rg$. The tensile stress, however, in the rim acting tangentially as in **169** amounts to

$$\frac{\text{weight of rim} \times v^2}{2\pi rg}.$$

The Purpose of Flywheels. The main purpose of the flywheel is to provide a reservoir of energy. In the steam engine, and also in gas and oil engines, the energy is supplied in jerks, as it were, at brief intervals, while the work to be done—the resistance to be overcome—is a constant quantity. This intermittent supply of energy is sometimes noticeable in steamers propelled by paddle-wheels as a monotonously regular forward jerk. But the enormous mass of a steamer, a locomotive, or a train is sufficient to store up the excess of energy during the period when the supply is greater than the demand, and to part with it when the resistance exceeds the power supplied. Hence, it is hardly necessary to say that a flywheel is not required in marine or locomotive engines. There is another case where a flywheel is needed —when the energy imparted is used periodically instead of regularly. Punching and shearing machines are an example of this intermittent utilisation of energy. The accumulated energy of the flywheel is sufficient to produce the operation of punching, shearing, slotting, etc., when without its aid the engine would possess insufficient power to perform these operations.

The Stored Energy of Flywheels. The energy acquired by the flywheel is called "kinetic energy." Work is performed by the flywheel in virtue of its *motion* just as the



167-179. GOVERNORS, EMERY-WHEELS, AND HAMMERS

potential energy of a pile-driver enables it to perform work in virtue of its *position*. Work is done until the body possessing kinetic energy is brought to rest. The kinetic energy of a moving body of mass m

$$= \frac{m \times v^2}{2g},$$

and in the case of a wheel the velocity in feet per second

$$= \frac{2\pi r \times n}{60},$$

where n is the number of revolutions per minute. Therefore kinetic energy of flywheel

$$= \frac{m \times \left(\frac{2\pi r \times n}{60}\right)^2}{2g} = \frac{m \times 4\pi^2 r^2 \times n^2}{2g \times 3600} = \frac{m \times \pi^2 r^2 \times n^2}{2g \times 900}.$$

Inspection will show that for one particular flywheel all the quantities in this equation are constant except n. Hence the kinetic energy depends directly on the square of the number of revolutions in a minute, while for different wheels the energy is proportional to the mass and the square of the velocity.

Practical Issues. It must not be imagined that the design of an engine governor is so simple a matter as to be embodied in the formulæ just given. If such were the case, there would not be so large a number of variations in design. Many of these are veritable puzzles to the uninitiated. But if we consider for a moment or two what a governor is expected to do in the modern factory or generating station, we shall at least understand that the problems presented are not so easy of solution as they appear on first thoughts.

Conditions of Governing. The most exacting conditions are those that exist in cotton-spinning mills and in electric generating stations. A variation of about 2 per cent. in the number of revolutions per minute of a high-speed engine is as much as is consistent with steady, satisfactory working. Two per cent. is a very small margin when we remember that the governor cannot begin to act until the speed of the engine changes. Hence the necessity for responsiveness, a need which increases with speed. So that the difficulties of fitting governors instantly responsive are much more difficult of solution than they were in the old days of slow-running engines, for which the Watt governor answered well enough. A very brief account of some of the principal devices is all that can be given here, bearing in mind that however diverse the forms, the principle remains unaffected—that is, the centrifugal force and gravity must be in equilibrium. It is necessary also to mention that improvements are not wholly to be credited to the governors alone, but also to better forms of throttle-valves, as those of double-beat type, which are more delicate and precise in action than the old elliptical throttle-valve.

Crossed-arm Governors. The early type of Watt governor is shown in 168. where h is the height of the cone, measured from the radius line r to the apex. This governor is too sensitive, because the height h varies greatly and rapidly with changes of speed. As the number of revolutions per second varies inversely as the square root of h, it is not possible for the engine to run regularly. A better form is that in which two points of suspension are provided at some distance below the apex, because as the balls rise, the apex drops, and therefore there is less effect on the height of h than in the previous case, and the balls have to move a less distance to effect a change in speed. The best form possible in this design is the crossed-arm governor [**171**], where h remains nearly constant for all variations in load. This is approximately isochronous, or astatic, a condition which is best fulfilled when the balls move in a parabolic path, and these do so nearly. But it is not a perfect governor, because it is liable to *hunt*, due to its sensitiveness. That is to say, it is too quickly responsive to minute changes, with the result that it will sometimes produce, instead of check, changes. Hence, pseudo-astatic governors, or those in which the too rapid action is checked by springs or weights, are preferred. Moreover, one essential condition to responsiveness is that the governor shall run more rapidly than the engines, so that with the high-speed engines of to-day the speeds of governors have to be very high. Some contrasts are shown by the figures.

Fig. **171** is a good pattern of crossed-arm governor, approximately astatic. It is driven by the small belt pulley A through bevel wheels B to the spindle C, carrying the crosshead D, from which the arms are suspended. The sliding sleeve E receives the connecting rods by which the vertical movements of the arms are transmitted to the lever F, the spindle G of which actuates the throttle valve in any convenient way.

Centre-weighted Governors. A much better type is the centre-weighted, or Porter, governor [**172**], made also with many variations in the details of fitting. Here—the example being by Tangyes, Ltd.—the balls are connected to rods above and below, forked to embrace the top of the vertical spindle, and the lower portion of the central weight A. As they fly outwards, therefore, they raise the weight, but their movement is also checked by its resistance. The throttle lever B is actuated as before, through a forked end, and the governor is belt driven also by the pulley and bevel gears seen below.

Spring Governors. In another large group of governors the resistance of a spring is utilised to check the opening of the balls. In these the resemblance to the Watt is not obvious. There are many, as the Hartnell [**173**], Burrell, Robey [**174**], and others. The power of the spring is adjustable. In **174** the governor controls the action of two sets of valves, as shown, with dashpots.

Slip is fatal to the accurate working of governors, hence the belt driving is often abandoned; chain driving by a Renold chain sometimes takes its place, but more often the governor is put on the crank-shaft.

Many governors exercise direct control over the slide valves through the slot links, an illustration of which occurs in 173.

Flywheels. These are dangerous objects unless the results of centrifugal force are safeguarded in some way. Many flywheels have fractured, with results disastrous to property and fatal to life. The following are the methods adopted in modern practice.

Cast - iron Flywheels. In casting these, the first difficulty lies in the shrinkage of the metal in unequal sections. Thus, the rim alone is considered in apportioning the mass of revolving metal, the arms being neglected, as far as their mass is concerned. Their only function is the due connection of the rim with the boss, and this is a point of cardinal importance—the embodiment of sufficient strength to resist the pulling or tensile action of the rim, and to resist the effect of stresses set up by the shrinkage of the cooling metal. The latter alone has been the primary cause of many fractures of wheels, although the strength of the arms, as obtained by calculation, was ample.

Causes of Ruptured Flywheels. When a flywheel cools after casting, the rim and central boss remain hot much longer than the arms, and so continue to shrink after the arms have set rigidly. This is where the mischief occurs. The shrinking rim and boss subject the arms to mixed stresses, and the arms resist the shrinkage of the rim and boss. The net result is that though the wheel does not fracture at the time of cooling, yet it is in such a condition of internal stress or tension, that a slight excess of speed of revolution above the normal is liable to fractur. it. It is a fact that the majority of flywheel fractures arise from this cause alone. Much can be done by care on the part of the designer and founder to proportion the rim, arms, and boss; or by hastening the cooling of the rim and boss, and delaying that of the arms, so that the cooling shall take place in about equal times. This is properly done in cast-iron flywheels; but as there is always an element of risk, the practice has grown of abandoning such wheels in favour of those built up in separate pieces, bolted together, and in another direction of using arms of wrought iron in rims and bosses cast around the ends of the arms.

Though, therefore, cast iron is used for wheels of small and moderate dimensions, the composite wheels are almost invariably used for those of large dimensions.

Wheels with Wrought - iron Arms. In these the arms are cut off from the bar, jagged at the ends, and inserted in the mould with the jagged ends projecting into the spaces prepared for rim and boss, and the metal is poured round the ends, so enclosing them. There are two objections to this, one being the flimsy, skeleton-like, unsightly appearance of the arms; and secondly, the real risk of the arms becoming bent by the centrifugal efforts of the rim, an accident which has frequently happened. Hence the reason why the built-up wheels have preference.

Built-up Composite Wheels. Of these there are several designs, the best of which are found in mill engines, often combined with toothed wheels. Various means of union are adopted. The rim is cast in segments, and united with cottared dowels. The arms are cast individually, and bolted to the rim across the joints of the latter, and also bolted to a central boss. Or sometimes the boss segments are cast with the arms, and bonded with wrought-iron rings to maintain them truly.

Grinding Wheels. Revolving masses are continually exercising the ingenuity of the mechanic. The modern practice of grinding as a rival to purely cutting operations has given an immense impetus to the development of the use of rapidly rotating wheels of emery, corundum, carborundum, etc. Comparisons with the old-fashioned grindstone crawling slowly round at about 100 revolutions per minute gives no manner of idea of the emery wheels of to-day. The latter run at a peripheral speed of about 5,000 ft. per minute, and this subjects them to a tensile stress tending to burst them of about 75 lb. per square inch. Of course, such wheels do sometimes fracture, but evil results rarely follow, because provision is made with a view to prevent the fragments from flying asunder. This takes two forms. In one [**175**, **176**, and **177**] the body of the wheel is so gripped by bosses that, even though it breaks, the pieces are still retained. In the other [**178**] a hood (A) encircles the wheel, excepting just at the locality where the actual grinding is being done, and so confines fractured portions.

Centrifugal force has to be carefully considered in connection with the armature windings of dynamos and motors. If these are not secured efficiently with bonds, the wires will fly outwards, and so work loose.

High-speed Shafts. A dynamical effect of much practical importance arises out of the rotation of unbalanced shafts, particularly that of crank shafts. The counterbalance weights put in the driving wheels of locomotives are carefully calculated and located to neutralise the dynamical effect of the two cranks, which are situated at right angles to each other, and by which the driving wheels are rotated through pistons and connecting-rods. They do for the crankshaft what the flywheel does for the ordinary steam engine. But for these cranks the motion of the engine would produce a succession of hammer-like blows on the rails, destructive alike to the rails and the mechanism of the engines.

The cranks of compound marine engines are balanced, but in a different way. Extensions are forged on the cranks at the side opposite to the crank.

When there are three cranks situated at angles of 120°, no counterbalancing is necessary, because the cranks balance each other round the axis.

Precautions with High-speed Pulleys. Plain shafts and pulleys, having no sensible lopsidedness, often develop wobbling or vibratory movement at high speeds. In the case of pulleys this is obviated, at the speeds at which they generally run, by balancing them in the course of manufacture on knife edges, and carefully removing metal from those portions which come to rest in the lowermost positions. This is

necessary in all high-speed pulleys. But shafts, though turned truly, do at a very high speed—the *critical speed*—develop vibration which often subsides at a higher or lower speed. In such cases extra bearing support must be afforded, or the shafts must be stiffened without increasing their weight. This explains, too, why stiffness in a shaft is of greater importance than mere torsional strength. The latter alone would yield impracticable results. It also explains why steel has superseded iron for shafting in present-day design.

Pulleys and drums of great weight on light shafts inevitably set up vibrations, in spite of good balancing; hence it is necessary to lighten them where possible. In present practice, pulleys of rolled steel have largely superseded the heavier ones of cast iron; and those built of timber, lighter than steel, enjoy a rapidly growing popularity.

Hammers. Of the gravity mechanisms pure and simple, perhaps the most obvious are the pile-driving monkeys, and the steam and drop hammers. Here foot-pounds = lb. weight multiplied into the height fallen in feet, represents the dynamical effort. In either case the monkey, or the tup, is the weight usually taken as the falling weight, though in steam-hammers [**179**] the weight of the piston and piston-rod should be included. An advantage of all these mechanisms is that one of the factors is capable of variation, that of the height of fall. In the pile-driver, the winch by which the monkey is raised regulates it; in the steam-hammer it is the volume of steam admitted; in the drop-hammer the height is regulated by the belt or board.

Although we have spoken of the falling weight of a hammer only, few steam-hammers are made like this now, but the pressure of steam is introduced to accelerate the descent of the tup. This increases the speed of working, enabling many more blows to be struck in a given time, in addition to the greater dynamic effect. Hammers are made generally to operate by working a hand-lever for each blow, or self-acting, as in the type shown in **179**. Note should be made of the great relative mass of the anvil-block A, of cast iron, which is absolutely necessary to enable it to absorb the blows without excessive vibration.

The Hammer Blow. The energy of the blow of a hammer is expressed in foot-pounds, and may be ascertained by the following formula:

a = Area of piston in square inches.
p = Average pressure of steam on piston during downward stroke in pounds per square inch.
S = Stroke of piston in feet.
W = Falling weight in pounds.
E = Energy of blow after full stroke, and before striking, in foot-pounds.

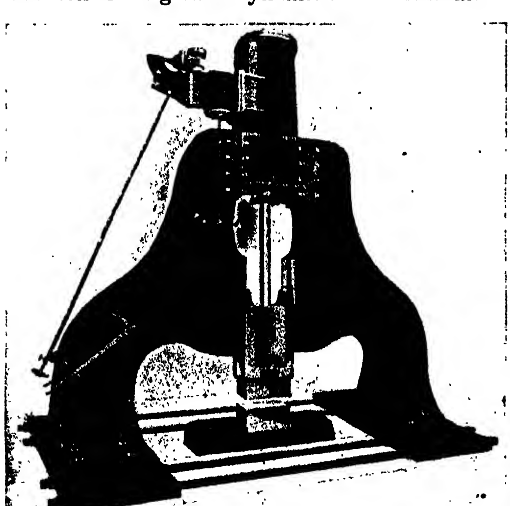
$$E = (ap + W)S.$$

The velocity of the tup the instant before striking may be calculated by the following formula:

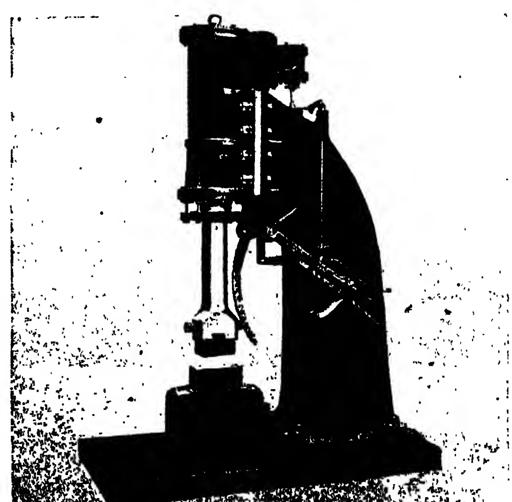
P = Total pressure on piston = pa.
F = Total force causing downward acceleration = $P + W = pa + W$.
g = Acceleration due to gravity = 32·2.
V = Velocity after full stroke and before striking, in feet per second.

$$V^2 = \frac{2FgS}{W}.$$

The force of a blow cannot be stated in terms of weight at all, because the pressure of a weight is continuous, whereas the force of a blow is expended in a moment. Messrs. B. & S. Massey, the steam-hammer makers, have, however, ascertained by careful experiments that the maximum blow of a 5-cwt. double-acting steam-hammer, with moderate steam pressure, produces a crushing effect upon a piece of hot iron as great as that produced by a load of about 30 tons, and a ½-cwt., double-acting steam-hammer, a crushing effect equal to that produced by a load of about 2½ tons. JOSEPH G. HORNER



TEN TON ARCH-FORM STEAM-HAMMER, WITH HAND-WORKED VALVE GEAR



HALF-TON STEAM-HAMMER, WITH SELF-ACTING AND HAND-WORKED VALVE GEAR

From photographs by courtesy of Messrs. B. and S. Massey, Manchester

Spanish: Conditional Mood. Indefinite Adjectives and Pronouns.
French: Demonstrative Pronouns. German: Strong Verbs.

SPANISH

Continued from page 2230

By José Plá-Cárceles, B.A.

Conditional Mood. The conditional mood is formed by adding the terminations *ía, ías, íamos, íais, ían* to the infinite of all regular verbs.

CONDITIONAL MOOD OF *Comprar*

Singular	*Plural*
comprar-ía, I should buy	*comprar-íamos*, we should buy
comprar-ías	*comprar-íais*
comprar-ía	*comprar-ían*

Second Conjugation: *beber-ía, beber-ías*, etc., I should drink.

Third Conjugation: *cumplir-ía, cumplir-ías*, etc., I should fulfil.

When the future tense of a verb is irregular, the conditional mood is formed by adding the above terminations to the stem of the future.

Infinite	*Future*	*Conditional*
saber, to know	*sabré*	*sabría*
poder, to be able	*podré*	*podría*
decir, to say	*diré*	*diría*
salir, to go out	*saldré*	*saldría*

The conditional mood of *ser* and *estar* is regular. —*sería, estaría*; that of *tener* and *haber* is irregular.—*tendría, habría*.

EXERCISE XXXI

the failure	*el fracaso*	the excess	*el exceso*
a port	*un puerto*	expenses	*gastos*
to imply	*implicar*	to appoint	*nombrar*
consignee	*consignatario*		
on any account	*de ningún modo*		
representative	*agente*		
by sailing vessels	*por barcos de vela*		

1. Would you sell it at that price? 2. No; it would be a failure. 3. What would you advise me? 4. I should explain it to him again. 5. The consignees would not pay the excess on any account. 6. Do you think that it would be cheaper to send the goods by sailing vessels? 7. We should have to appoint representatives in several ports. 8. Would it not be better to wait? 9. That would imply greater expenses.

Indefinite Adjectives and Pronouns. The following indefinite adjectives and pronouns take the gender and number of the substantive to which they refer:

how much	*¿ cuanto ?*	much	*mucho*
too much	*demasiado*	little	*poco*
any, some	*alguno*	none	*ninguno*
same	*mismo*	all, the whole	*todo*
other, another	*otro*		

"How many" is rendered by *cuant-os, -as*; "many," by *much-os, -as*; "too many," by *demasiad-os, -as*; and "few" by *poc-os, -as*.

"Any" and " " used as partitive adjectives in front of a singular noun are either omitted or translated by *un poco de* (lit., a little of).—*compre Vd. carne* (or *un poco de carne*), buy some meat. When the following noun is in the plural, "some" and "any" are either omitted or rendered by *algunos* or *unos*.—*¿ tiene hermanos ?* has she any brothers?

The words *algo*, something; *nada*, nothing; *alguien*, anybody, somebody; and *cada*, each, every, are invariable. After a negation, "anybody" and "any" are respectively rendered by *nadie* and *ninguno*.—*no ha escrito á nadie*, she has not written to anybody.

EXERCISE XXXII

to meet	*encontrar*	the frontier	*la frontera*
to stop	*parar*	an armchair	*un sillón*
the circular	*la circular*	comfortable	*cómodo*
a branch	*una sucursal*	printed	*impreso*
the things	*las cosas*	I think so	*creo que sí*
the garden	*el jardín*	by post	*por correo*
Scotland	*Escocia*	Colombia	*Colombia*
both	*ambos*	the back	*la espalda*
a handkerchief	*un pañuelo*		
the opinion	*la opinión*		
an application	*una solicitud*		

1. How many printed circulars did you send by post? 2. I have not sent any today. 3. Has anybody been here this morning? 4. No, sir; nobody has come. 5. He used to spend too much money. 6. That bank has too many branches in Colombia. 7. Please give me some more milk. 8. Do you wish anything? 9. No; I do not wish anything. 10. Do they sell any German newspapers? 11. I think so. 12. Where did you buy those handkerchiefs? 13. I bought all the things at the same shop. 14. Each house has a small garden at the back. 15. All (the) trains stop at the frontier. 16. He has given me something. 17. We met some friends at the theatre. 18. The other armchair is more comfortable. 19. We receive very few orders from Scotland. 20. Both are of the same opinion.

Some Remarks on the Adjectives. There are many adjectives which can be used as nouns and then become subject to all the rules governing substantives, as, for instance, *jóven*, young; *un jóven*, a young man; *francés*, French; *un francés*, a Frenchman.

Grande, great, when it implies merit, loses the final syllable and is placed before the noun.—*un gran pintor*, a great painter. When it refers to size it is placed after the noun.—*un edificio grande*, a large building.

The masculine adjective *santo*, saint, drops the last syllable before all proper names except *Domingo, Toribio*, and *Tomás*.—*San José*, Saint

Joseph; *Santo Tomás,* Saint Thomas. The feminine *santa* is invariable.—*Santa Lucía,* Saint Lucy; *Santa Isabel,* Saint Elizabeth.

Diminutive and Augmentative Suffixes. Diminutive and augmentative suffixes are terminations applied to nouns and adjectives, qualifying their original meaning. Their correct use is rather difficult, and can only be learned properly by practice. Students should therefore refrain from using them until they master the language. In the meantime, adjectives should always be used in their place.

Diminutives express smallness, fondness, and sometimes pity or contempt. The chief diminutive terminations are *ico, ito, illo, uelo.* All these terminations change the final *o* into *a* in the feminine.

The principal augmentative terminations are *ón, azo, ote* in the masculine, and *ona, aza, ota* in the feminine. These terminations simply imply largeness, but *achón* further expresses clumsiness and contempt. Diminutives are frequently applied to proper names. Examples of both types of suffixes are: *una casita,* a little house; *un perrazo,* a big dog; *la callejuela,* the narrow lane; *una mujerona,* a big woman; *el cigarillo,* the cigarette; *un borrachón,* a drunkard; *un muchachote,* a big boy; *un hambión,* a hungry fellow; *un poquito,* a little bit; *Pepito,* Joe; *Anita,* Nancy.

Reading Exercise
El Público

Esa voz "público," que todos traen en boca siempre, en apoyo de sus opiniones, ese comodín de todos los partidos, de todos los pareceres, ¿es una palabra vacía de sentido, ó es un ente real y efectivo? Según lo mucho que se habla de él, según el papelón que en el mundo hace, según los epítetos que se le prodigan, y las consideraciones que se le guardan, parece que debe de ser alguien. El público es ilustrado, el público es indulgente, el público es imparcial, el público es respetable; no hay duda, pues, en que existe el público. En este supuesto, ¿Quién es el público y donde se le encuentra? Salgo de casa con mi cara infantil y bobalicona á buscar al público por esas calles, y á tomar apuntaciones en mi cartera acerca del carácter, por mejor decir, de los caracteres distintivos de ese respetable señor. Reuno mis notas y más confuso que antes acerca del objeto de mis pesquisas, llego á informarme de personas más ilustradas que yo. Un autor silbado me dice cuando yo le pregunto, "¿Quién es el público?" "Preguntadme más bien cuantos necios se necesitan para componer un público." Un autor aplaudido me responde, "Es la reunión de personas ilustrados que deciden en el teatro del mérito de las producciones literarias."

Translation of Reading Exercise
The Public

This word "public," which is always in every man's mouth in support of his opinions, this accommodating servant of every party and every opinion, is it a word void of meaning or is it a real and actual living being? According to the amount of talk there is about it, according to the prominent part it plays in the world, according to the titles lavished upon it, and the consideration shown it, it seems as if it ought to be somebody. The public is enlightened, the public is indulgent, the public is impartial, the public is respectable. There can be no doubt, therefore, that the public exists. Such being the case, who is the public, and where is it to be found? With a youthful and ingenuous countenance I leave my house to search for the public in the streets, and to take notes in my pocket-book of the character, or rather of the distinctive characteristics, of this worthy gentleman. I gather up my notes more perplexed than ever as regards the object of my inquiries, and seek information from persons more learned than myself. To my question "Who is the public?" an author who has been hissed replies, "Ask me rather how many fools are required to make a public." An author who has been applauded replies, "It is the assembly of enlightened persons who decide upon the merit of literary productions in the theatre."

Key to Exercise XXVII

1. Haga Vd. el favor de enviarnos los géneros franco á bordo. 2. ¿Cuanto pagaba Vd.? 3. Quince pesos al mes. 4. ¿Cuando se lo explicará (á ellos)? 5. Ya se lo ha explicado. 6. Espéreme Vd. fuera. 7. ¿Sabe su socio español? 8. Muy poco, pero lo está estudiando ahora. 9. ¿Practica con Vd. algunas veces?. 10. No, nunca prueba á hablar conmigo. 11. Yo lo hablaba bastante bien pero casi lo he olvidado. 12. ¿Irán Vds. al teatro esta noche? 13. Creo que no; siempre llegan demasiado tarde. 14. Haga Vd. el favor de decirme como pronuncia esa palabra. 15. Con mucho gusto. 16. ¿Donde veré á Vd. despues? 17. Estaré aquí, dentro de una hora. Adiós. 18. ¿Sabe Vd. si las oficinas están arriba? 19. No, señor; ahora están abajo. 20. No tiene ni amigos ni parientes.

Key to Exercise XXVIII

1. ¿Comprendió Vd. la canción? 2. No; cantó en italiano aquella noche. 3. Esperamos dos horas por lo menos; ¿á que hora llegó el tren? 4. Más tarde que nunca. Casi á las ocho y media. 5. ¿Cuanto le costó (á Vd.) el viaje? 6. Tomé un billete de ida y vuelta que es mucho más barato. 7. ¿Cuando comenzaron los contratistas á construir el muelle? 8. Creo que comenzaron poco despues de Pascua. 9. ¿Comprobó Vd. todas las facturas? 10. No; no tuve tiempo para comprobarlas todas. 11. ¿Llovió? 12. Solamente por la noche. 13. ¿Esperaron en casa? 14. No; salieron á saludarle. 15. ¿Donde ancló el vapor? 16. En medio de la bahía. 17. No comprendo porque no contestaron mi telegrama en el acto. 18. ¿Sabe Vd. lo que decidieron respecto al viaje? 19. Sí; acordaron viajar con él hasta Vigo. 20. ¿Cuanto tiempo duró la batalla? 21. Un par de horas. Según la últimas noticias dos regimientos tomaron la fortaleza por asalto. 22. Vd. habla inglés muy bien; ¿donde lo aprendió Vd.? 23. Estuve nueve meses en Londres donde tuvo un profesor muy bueno.

Key to Exercise XXIX

1. Veinte buques. 2. Cincuenta y tres chelines. 3. Setenta y nueve páginas. 4. Cuarenta y cinco cajas de azúcar. 5. Ciento siete libras. 6. Trescientos sesenta y cinco días. 7. Seiscientos trece árboles. 8. ¿ Cuantos años tiene ahora ? 9. Tiene setenta y cinco. A los veintitrés años de edad mandaba una fragata de ochenta y cuatro cañones. 10. ¿ Que edad tenía Vd. entonces ? 11. Tenía quince años. 12. En mil setecientos Davenant calculó la producción anual de todas las minas de Inglaterra entre setecientas y ochocientas mil libras. 13. El área del Canadá es de tres millones cuatrocientas setenta mil millas cuadradas, lo cual es casi equivalente á la superficie territorial de Europa. 14. Las bajas del enemigo fueron mil cincuenta hombres muertos, mil setecientos heridos y dos mil quinientos prisioneros. 15. En mil ochocientos cuarenta y cuatro, el ingreso líquido de las aduanas de Liverpool ascendió á cuatro millones trescientas sesenta y cinco mil quinientas veintiseis libras, un chelín y ocho peniques.

Key to Exercise XXX

1. Fuma un par de pipas despues de la comida. 2. Yo viajaba en tercera clase. 3. Están viviendo ahora en el quinto piso del mismo edificio. 4. Lo leí en el primer capítulo. 5. ¿ Lo prestó Vd. el tomo veinte del a Biblioteca Española ? 6. Desembarcamos en Valparaíso el ventiuno de Diciembre de mil ochocientos setenta y nueve. 7. Su mujer nació el seis de Enero de mil ochocientos ochenta y seis. 8. El treinta de Agosto será el cumpleaños de su primer hijo. 9. ¿ Qué fecha es hoy ? 10. El diecinueve de Febrero. 11. Felipe Tercero ascendió al trono de España en mil quinientos noventa y ocho. 12. En mil cuatrocientos noventa y tres, el Papa Alejandro Sexto concedió á los reyes Católicos derechos exclusivos sobre el Nuevo Mundo. 13. El Emperador Carlos Quinto expiró el veintiuno de Septiembre de mil quinientos cincuenta y ocho, á la edad de cincuenta y ocho años, seis meses y veinticinco dias. 14. Al final del siglo diecisiete la población de Inglaterra era de cinco millones doscientas mil almas. 15. El arqueo de los vapores del puerto de Londres ascendió, al final de mil ochocientos cincuenta y cuatro, á ciento treinta y ocho mil toneladas, sin contar los buques de menos de cincuenta toneladas. 16. En el reinado de Carlos Segundo - escribe Macaulay—ni una sola ciudad provinciana del reino contenía treinta mil habitantes y solamente cuatro tenían diez mil. 17. Durante un cuarto de siglo, la proporción de nacimientos en Italia permaneció casi estacionaria á treinta y siete por mil. 18. Una pulgada es igual á un doceavo de pie. 19. Cuatro mil quinientas sesenta y tres cienmilésimas.

Continued

By Louis A. Barbé, B.A.

DEMONSTRATIVE PRONOUNS

1. The Demonstrative pronouns (*pronoms démonstratifs*) are:

ce, it, that; *ceci*, *cela*, this, that; *celui* (m), *celle* (f), that, the one; *ceux* (m.), *celles* (f.), those; *celui-ci* (m.), *celle-ci* (f.), this, this one, the latter; *ceux-ci* (m.), *celles-ci* (f.), these, the latter; *celui-là* (m.), *celle-là* (f.), that, that one, the former; *ceux-là* (m.), *celles-là* (f.), those, the former.

2. *Ce* as a demonstrative pronoun is used either (*a*) before *être* (which may be preceded by a third person singular of *pouvoir* and *devoir*) or (*b*) as antecedent of the relative pronoun, the two together meaning "what," and *ce qui* being used as subject, whilst *ce que* is used as object:

c'est lui, it is he ;

ce peut être lui, it may be he ;

ce doit être lui, it must be he.

Ce qui est vrai n'est pas toujours agréable, what is true is not always pleasant ; *ce que vous m'avez dit est-il vrai ?* Is what you have told me true ?

3. *Ce* is used instead of *il, elle, ils, elles* before the verb *être*, when that verb is followed by a noun having an article, a demonstrative adjective, or a possessive adjective before it:

Qui est ce monsieur ? C'est le père de mon ami. Who is that gentleman ? He is my friend's father ;

Qui est cette demoiselle ? C'est ma sœur. Who is that young lady ? She is my sister .

Qui sont ces messieurs ? Ce sont des amis, Who are those gentlemen ? They are (some) friends.

4. When the noun which follows *être* is not accompanied by an article, etc., it has the value of an adjective, and the verb is then preceded by *il, elle, ils, elles :*

Il est soldat, he is a soldier ;

Elles sont institutrices, they are governesses.

5. When a third person singular of " to be " is preceded by " it," and followed by an adjective, the " it " is rendered by *il* if the adjective applies to a statement that is going to be made, and by *ce* if it applies to a statement that has just been made :

Je ne le connais pas, c'est vrai, I do not know him, it (that) is true ;

Il est vrai que je ne le connais pas, it is true that I do not know him.

6. *Ceci*, this, and *cela*, that (contracted into *ça* in ordinary conversation) do not refer to any noun mentioned before ; they can only be used in connection with objects, and not persons ; and they have no plural ; *Ceci* refers to the nearer object pointed out, and *cela* to the more remote :

Je n'aime pas ceci, donnez-moi cela, I do not like this, give me that.

7. *Ceci*, like " this," in English may refer to a statement that is going to be made ; and *cela*, like "that," to a statement just made :

Retenez bien ceci : Le pain que nous gagnons est le meilleur, bear this well in mind (lit., retain this well) : the bread we earn is the best.

La pratique rend maître, n'oubliez pas cela, practice makes perfect, do not forget that.

8. *Celui, celle, ceux, celles,* without either *ci* or *là* added to them, are used only in two constructions: 1st, before a relative pronoun; 2nd, before the proposition *de.* The latter construction renders the English possessive:

J'aime mieux votre livre que celui que j'ai, I like your book better than the one I have;

Je l'aime mieux que celui de votre frère, I like it better than your brother's.

POSSESSIVE PRONOUNS

1. Possessive pronouns (*pronoms possessifs*) of which the agreement, like that of the possessive adjectives, is with that which is possessed, and not with the possessor, are:

	Mas. Sing.	Fem. Sing.	
1st per. sing.	*le mien,*	*la mienne;*	mine
2nd per. sing.	*le tien,*	*la tienne;*	thine
3rd per. sing.	*le sien,*	*la sienne;*	his, hers
1st per. plur.	*le nôtre,*	*la nôtre;*	ours
2nd per. plur.	*le vôtre,*	*la vôtre;*	yours
3rd per. plur.	*le leur,*	*la leur;*	theirs

	Mas. Plur.	Fem. Plur.	
1st per. sing.	*les miens,*	*les miennes;*	mine
2nd per. sing.	*les tiens,*	*les tiennes;*	thine
3rd per. sing.	*les siens,*	*les siennes;*	his, hers
1st per. plur.	*les nôtres,*	*les nôtres;*	ours
2nd per. plur.	*les vôtres,*	*les vôtres;*	yours
3rd per. plur.	*les leurs,*	*les leurs;*	theirs

2. Possession is also expressed by means of the verb *être,* followed by the preposition *à* and a disjunctive personal pronoun:

Ce cheval est à lui, that horse belongs to him.

There is, however, a difference between *à moi,* etc., and *le mien,* etc. Ownership, and nothing else, is implied by *à moi,* etc., whilst *le mien,* etc., is used to distinguish the ownership of one object from that of others:

Cette bague est à moi, That ring belongs to me;

Cette bague est la mienne, That ring is mine (the others are not).

3. The English expression "of mine," etc., is rendered, not by the possessive pronoun, but by the possessive adjective:

He is a friend of ours, *C'est un de nos amis.*

4. *À moi, à toi,* etc., are used with the other possessives, both adjectives and pronouns, to emphasise them:

Est-ce de ma faute, à moi, qu'il n'ait pas réussi?

Is it *my* fault if he has not succeeded?

5. *À moi, à toi,* etc., preceded by *ce* + *être* and followed by *à* or *de* with an infinitive, form two idiomatic expressions expressing respectively duty, province, privilege, etc., and turn:

C'est à vous à commander, c'est à lui à obéir.

It is your province to command, it is his duty to obey.

C'est à vous de jouer, it is your turn to play.

Exercise XVII

1. This pen is good, but that is better.
2. She has shown (*montré*) me her hat and her sister's.
3. I like ours better than theirs.
4. If it is not he, it is his brother.
5. Who are those young ladies? They are our cousins.
6. Is this gentleman a barrister (*avocat*)? No; he is a doctor (*médecin*).
7. He is one of our most distinguished (*distingué*) doctors.
8. I do not know that gentleman; I have seen him once or twice, it is true, but I have never spoken to him.
9. It is true that we have never spoken to him, but we know (*connaissons*) him very well by sight (*de vue*).
10. Have you done that? No, it was (is) not I, it was he.
11. If you have any finer engravings (*gravures,* f.), show them to me; I do not like these.
12. What you have just read (*venez de lire*) is very interesting, but it is not true.
13. This room is smaller than ours; it is the smallest in the whole house.
14. Give me another handkerchief, please (*s'il vous plaît*); I have lost mine.
15. Our flowers are beautiful, your sister's are still (*encore*) more beautiful, but yours are the most beautiful.
16. That ring is not mine, I have none: it belongs to a friend (f.) of mine.
17. It is not *her* ring that she (*qu'elle*) has lost (*perdue*); it is mine.
18. Whose turn is it to play? It is yours.

Key to Exercise XV

1. Je cherche mon livre et mes plumes.
2. Vous avez parlé à mon frère et à ma sœur.
3. Il a donné un cadeau à son ami.
4. Il me cherche. 5. Elle vous parle.
6. Nous lui avons donné une montre.
7. Il ne leur parle pas.
8. Leur a-t-elle donné un cadeau?
9. A-t-il trouvé sa montre?
10. Je te donne cela, me dit-il.
11. Donnez-le-moi, nous dit mon père.
12. Achète-toi un parapluie.
13. Nous nous levons tous les jours à sept heures.
14. Ils ne se couchent jamais avant onze heures. 15. Nous le leur donnons.
16. Elle vous la prête.
17. Il nous en a donné.
18. Vous nous en avez parlé.
19. Si vous avez de l'argent, donnez-lui-en.
20. Ne lui en parlez pas.
21. Nous ne nous y opposons pas.
22. Si vous cherchez vos gants, les voici.
23. Vous vous trompez.
24. Ils se flattent.

Key to Exercise XVI

1. Ils sont contre moi et pour eux.
2. Elle ne se fie pas à lui.
3. Qui avez-vous vu? Lui.
4. Qui leur a répondu? Eux.
5. Qui est là? C'est moi.
6. Nous irons ensemble, toi et moi.
7. Il nous a parlé, à lui et à moi.
8. Nous y avons été plus souvent qu'eux.

9. Elle est plus intelligent que lui.
10. Eux, que nous croyions nos amis, nous ont trahis.
11. Il travaille, lui, mais toi, tu ne fais que jouer.
12. Lui dire une telle chose !
13. Eux ont fourni l'argent, lui a bâti la maison.
14. Si vous ne me croyez pas, moi, le croirez-vous, lui ?
15. Cet enfant a écrit la lettre lui-même.
16. Elles m'ont dit elles-mêmes qu'elles viendraient ce soir.
17. Ils ne sont jamais chez eux le soir.
18. Chacun pour soi et Dieu pour tous.

Continued

GERMAN

Continued from page 2236

By P. G. KONODY and Dr. OSTEN

XXXIV. SUBSTANTIVES ONLY USED IN THE SINGULAR. Many *abstract* nouns which, being in themselves collective and synthetic terms, have no plural, as: die Furcht, fear, terror; der Neid, envy; der Glanz, splendour; der Geiz, avarice; die Jugend, youth; die Unſchuld, innocence, etc.; such *concrete* nouns, as: der Sand, the sand; der Schnee, the snow, etc.; and all nouns that are not substantives, but are used substantively, as: das Tanzen, the dancing; das Außerordentliche, the extraordinary. The concrete *effects* of abstract ideas and actions form a plural either in the ordinary way, or by circumlocution: die Dumm'heit (*s.*), stupidity; die Dummheiten (*pl.*), acts of stupidity, foolishness; das Glück (*s.*), luck, fortune; die Glücksfälle (*pl.*), strokes of luck; das Un'glück (*s.*), misfortune; die Un'glücksfälle (*pl.*), strokes of misfortune; der Betrug' (*s.*), fraud; die Betrügerei'en (*pl.*), fraudulent acts; der Dank (*s.*), thanks; die Dank'bezei'gungen (*pl.*), expressions of thanks.

1. The names of materials have as a rule no plural, but where different *kinds* of one material are concerned a plural can be formed, for instance: das Holz, (*s.*), wood, die Hölzer (*pl.*), different sorts of woods; das Geld (*s.*), money, die Gelder (*pl.*), the sums; das Gras (*s.*), grass, die Gräſer (*pl.*), the grasses; das Getrei'de (*s.*), cereals, die Getrei'dearten (*pl.*), the different kinds of cereals; das Korn (*s.*), corn, die Körner (*pl.*), the grains.

2. Some collective nouns are only used in the plural: die El'tern, the parents; die Geſchwi'ſter, German collective for brothers and sisters; die Gebrüder, brothers (when defining a business firm: Gebrüder Hope, Hope Brothers); die Leute, folk, people; die Oſtern, Easter; die Pfingſten, Whitsuntide; die Faſten, fasting, Lent; die Fe'rien, the vacation, holidays; die Blattern, smallpox; die Ma'ſern, measles; die Zinſen, interest (on capital), etc. Collective nouns denoting mountain ranges: die Alpen, the Alps; die Anden, the Andes; die Cordilleren, the Cordilleras; die Voge'ſen, the Vosges; but der Jura (*s.*), der Harz (*s.*), der Balkan (*s.*).

XXXV. The DEMONSTRATIVE PRONOUNS are: der (*m.*), die (*f.*), das (*n.*), that (not to be confounded with the definite article der, die, das); dieſer, this; jener, that; ſolcher, such, *or* such a; derjenige, he, *or* that; derſelbe, the same; (the two last being compounds of der and jenige, and der and ſelbe), each with three genders and one plural form.

The declension of the demonstrative pronoun der, die, das, differs only in the variation of the genitive and dative from that of the definite article.

	Singular		Plural	
nom.	der, die, das,	that	die	those
gen.	des (deſſen), der (deren), des (deſſen),	of that	der (deren, also derer),	of those
dat.	dem, der, dem,	to that	den (denen),	to those
acc.	den, die, das,	that	die	those

1. The alternative genitive and dative form (deſſen, deren, denen) is employed when the pronoun is used substantively: Die Blätter der Eiche unterſcheiden ſich von denen der Pappel, The leaves of the oak differ from those of the poplar. Obgleich England nicht ſo viele Soldaten hat als Deutſchland oder Frankreich, hat es deren genug, um ſeine Kolonien zu verteidigen, Although England has not as many soldiers as Germany or France, it has enough [of them] to defend its colonies.

(*a*) Deſſen and deren are also used as substitutes for the possessive pronouns ſein, his, and ihr, her, to avoid ambiguity. Example: der Vater erzählte von ſeinem Freunde und ſeiner Reiſe, The father spoke of his friend and of his journey. It is not clear whether the journey is that of the father or that of the friend; if the latter, deſſen must be substituted for ſeiner: der Vater erzählte von ſeinem Freunde und von deſſen Reiſe.

(*b*) The alternative plural genitive derer is only used when followed by the relative pronoun welcher and der (who, which): Das Him'melreich iſt derer, welche (die) Gott vertrauen, The Kingdom of Heaven is of those [belongs to those] who trust in God.

2. Dieſer, dieſe, dies (or dieſes), this; and jener, jene, jenes, that, follow the strong declension of the adjective [see XXVI.].

3. Solcher, ſolche, ſolches, such a, also follows the strong declension; but if used with the indefinite article it takes the inflections of the weak declension: ſolch-em Freunde (strong), to such a friend; but einem ſolch-en Freunde. Sometimes it is used in the shortened form ſolch for all three genders, followed by the indefinite article and without inflections: ſolch ein Mann, such a man; ſolch einer Frau, of such a woman; ſolch einem Freunde, to such a friend; ſolch einen Vater, such a father, etc.

4. In the compounds derjenige, diejenige, dasjenige, and derſelbe, dieſelbe, daſſelbe, der-, die-, das- take the strong, and -jenige, -ſelbe take the weak inflections.

	Singular	Plural
nom.	derjenige, derſelbe, etc.	diejenigen, dieſelben,
gen.	desjenigen, deſſelben, etc.	derjenigen, derſelben.
dat.	demjenigen, demſelben, etc.	denjenigen, denſelben.
acc.	denjenigen, denſelben, etc.	diejenigen, dieſelben.

Both these forms are always followed by the relative pronoun welcher, etc., or der, etc.: Derjenige, welcher (or der) Wind säet, wird Sturm ernten, He who sows wind will reap storm. Derjenige (or der) Mann ist der stärkste, welcher (or der) allein ist, The strongest man is he who is [strong] alone. Es war derselbe Mann, den ich sah, It was the same man whom I saw.

5. The neuters of the demonstrative pronouns are not used with prepositions, but are replaced by compounds of these prepositions with the adverb of place da (dar before vowels): damit, with this (instead of mit dem, diesem, demselben); davon, of this, from this (instead of von dem, etc.); dadurch, through this; daraus, out of this, etc. These contractions also replace the dative and accusative of dieser and jener, and of the personal pronouns if they refer to inanimate objects. Examples: Hier ist ein Gewehr, spiele nicht damit, Here is a rifle, do not play with it (damit replaces mit ihm, or mit demselben); ich warte darauf (instead of auf es, or auf dasselbe), I am waiting for it; wir sprechen noch darü'ber (instead of über das, über dieses, über es), We shall return to this subject [we will still speak about this].

6. The neuter demonstratives dies (lengthened: dieses) and das are applied, with the auxiliary verb of tense sein, to substantives, without the usual agreement in gender and number. Dies (dieses or das) ist mein Vater, dies meine Mutter, dies mein Kind, und dies sind meine Schwestern und Brüder, This is my father, this my mother, this my child, and these are my sisters and brothers.

XXXVI. Most *strong verbs* with the stem-vowel -e- change it in the imperfect into -a-, and in the past participle into -o- and -e- (which in

Infinitive		Present Tense I., II., III. Singular	Imperfect Indicative	Imperfect Subjunctive	Imperative	Past Participle
befeh'len	to command	ich befeh'le, befiehlst', befiehlt'	ich befahl'	ich befäh'le *	befiehl	befoh'len
ber'gen	to save, shelter	ich berge, birgst, birgt	ich barg	ich bärge	birg	geborgen
ber'sten	to burst	ich berste, birstest, birst	ich barst	ich bärste *	birst	geborsten
bre'chen	to break	ich breche, brichst, bricht	ich brach	ich bräche	brich	gebrochen
dre'schen	to thrash	ich dresche, drischest, drischt	ich drasch, also drosch	ich dräsche *	drisch	gedroschen
empfeh'len	to recommend	ich empfehle, empfiehlst, empfiehlt	ich empfahl	ich em-pfähle *	empfiehl	empfohlen
erschre'cken †	to terrify, to be frightened	ich erschrecke, erschrickst, erschrickt	ich erschrak	ich erschräke	erschrick	erschrocken
gel'ten	to tell, to be valid	ich gelte, giltst, gilt	ich galt	ich gälte *	gilt	gegolten
hel'fen	to help	ich helfe, hilfst, hilft	ich half	ich hülfe	hilf	geholfen
nehmen	to take	ich nehme, nimmst, nimmt	ich nahm	ich nähme	nimm	genommen
schelten	to scold	ich schelte, schiltst, schilt	ich schalt	ich schälte *	schilt	gescholten
sprechen	to speak	ich spreche, sprichst, spricht	ich sprach	ich spräche	sprich	gesprochen
ste'chen	to sting	ich steche, stichst, sticht	ich stach	ich stäche	stich	gestochen
stehlen	to steal	ich stehle, stiehlst, stiehlt	ich stahl	ich stähle *	stiehl	gestohlen
sterben	to die	ich sterbe, stirbst, stirbt	ich starb	ich stürbe	stirb	gestorben
treffen	to hit, to meet with	ich treffe, triffst, trifft	ich traf	ich träfe	triff	getroffen
verber'gen	to hide	ich verberge, verbirgst, verbirgt	ich verbarg	ich verbärge	verbirg	verborgen
verder'ben	to spoil	ich verderbe, verdirbst, verdirbt	ich verdarb	ich verdürbe	verdirb	verdorben
werben	to enlist, woo	ich werbe, wirbst, wirbt	ich warb	ich würbe	wirb	geworben
werfen ‡	to throw	ich werfe, wirfst, wirft	ich warf	ich würfe	wirf	geworfen
essen	to eat	ich esse, issest, isst	ich aß	ich äße	iß	gegessen
fressen	to eat (devour)	ich fresse, frissest, frisst	ich fraß	ich fräße	friß	gefressen
geben	to give	ich gebe, gibst, gibt	ich gab	ich gäbe	gib	gegeben
gene'sen	to recover	ich genese, genesest, genest	ich genas	ich genäse	genes(e)	genesen
gesche'hen	to happen, to take place	es geschieht	es geschah	es geschähe	gescheh(e)	geschehen
lesen	to read	ich lese, liesest, liest	ich las	ich läse	lies	gelesen
messen	to measure	ich messe, missest, misst	ich maß	ich mäße	miß	gemessen
sehen	to see	ich sehe, siehst, sieht	ich sah	ich sähe	sieh	gesehen
treten §	to step	ich trete, trittst, tritt	ich trat	ich träte	tritt	getreten
verges'sen	to forget	ich vergesse, vergissest, vergisst	ich vergaß	ich vergäße	vergiß	vergessen
gebären	to bear, to bring forth	ich gebäre, gebierst, gebiert	ich gebar	ich gebäre	gebäre, or gebier	geboren

* Also with ö. † As intransitive (without complement) *strong:* ich erschrak, I was frightened; as transitive (with object) *weak:* ich erschreckte ihn, I frightened him.

‡ To this group belongs also gebären, to bear, which is to be found at the end of the list of this group. § Also with haben in the sense of "to tread on."

the latter case means the return to the original stem-vowel). The verbs made prominent in print are conjugated with sein, all others with haben.

XXXVII. The Plural of Proper Nouns is formed in German as rarely as in English. Proper nouns shared by several persons, and those employed in a collective sense, remain sometimes unaltered in the plural—for instance: die beiden Frankfurt (*pl.*), the two towns of Frankfort; or add an -e, -en, -n, -r, -s, Ludwig (*s.*), Louis; and die beiden Ludwige (*pl.*); von Frankreich, the two Louis of France; but also die Ludwig (*pl.*), and die Ludwigs (*pl.*): die sieben Eduarde von England, the seven Edwards of England (also die Eduard and die Eduards); Maria or Marie (*s.*), Mary; and die Marien von Schottland, the Marys of Scotland. Proper nouns of Latin and Greek derivation either remain unaltered or form the plural like other substantives of foreign origin.

XXXVIII. The Double Plural. Several substantives with the same or double gender, and with the same or different meaning, form the plural in two different ways:

Singular	*Plural*	*Plural*
der Akt, document, act of a drama	die Akten, documents	die Akte, acts
der Band, volume,	die Bände, volumes	
das Band, tie, bond, ribbon	die Bande, fetters	die Bänder, ribbons
die Bank, bench, die Bank, bank	die Bänke, benches	die Banken, banks
der Bauer, peasant, das Bauer, birdcage	die Bauern, peasants	die Bauer, birdcages
der Bund, union, alliance das Bund, bunch	die Bünde, unions	die Bunde, bunches
das Gesicht, face, vision	die Gesichte, visions	die Gesichter, faces
der Laden, shop, shutter	die Läden, shops	die Laden, shutters
der Schild, shield, das Schild, signboard	die Schilde, shields	die Schilder, signboards
der Strauß, bunch of flowers, ostrich	die Sträuße, bunches of flowers	die Strauße, ostriches

1. Several other nouns form a double plural without, and some with, different meaning—*e.g.*; das Gastmal (*s.*), banquet, feast, die Gastmale (*pl.*) and die Gastmäler (*pl.*); der Ort (*s.*), place, locality, die Orte (*pl.*), places, and die Örter, communities; das Wort (*s.*), word, die Worte (*pl.*), words, and die Wörter (*pl.*), words in the sense of vocables; das Land (*s.*), country, die Lande (*pl.*) [rhetorical form], and die Länder (*pl.*) countries.

Exercise 1. Change the present tense of the sentences into the imperfect and perfect.

Ich binde einen Kranz; der Vogel singt; das Reh
I bind a wreath; the bird sings; the deer
springt und trinkt; das Werk gelingt; wir trinken
jumps and drinks; the work succeeds; we drink
Wein; das Wasser rinnt ins Thal; er schwimmt
wine; the water flows into the valley; he swims
ausgezeichnet; ich sitze im Garten; das Schiff sinkt;
excellently; I sit in the garden; the ship sinks;
die Glocke klingt laut; der arme Mann bittet um
the bell sounds loudly; the poor man begs for
eine Unterstützung; ich gewinne das Spiel;
assistance (aid); I win the game.

Exercise 2. Insert the missing demonstrative pronouns and other parts of the sentences:

Ein . . . . selten; . . . . ein . . . . ;
Such a friend is rare; such a friend is rare;
Er . . . . ;
He is the son of this man and of that woman;
wir sprachen mit (3) . . . . Knaben . . . . ;
we spoke to this boy and to those men;
. . . . . . viel . . . .
she spoke much of her daughter and of her
. . . . Erfahrungen . . ; der Himmel ist
[the daughter's] experiences; Heaven is
. . . . . gnädig, die ihn anrufen; der Jäger
gracious to those who appeal to it; the gamekeeper
marschierte hinter seinem Herrn und trug
marched behind his master and carried
. . . . Gewehr.
his [the master's] gun.

Exercise 3 (*a*). Rearrange the following sentences by putting the indefinite article *before* the demonstrative pronoun:

Es ist eine Freude, solch einen Sohn zu haben.
It is a joy to have such a son.
Solch' ein Un'glück! Solch' eines Mannes Sohn
Such a misfortune! The son of such a man
sollte von anderer Art sein. Wie konnten
ought to be of different stuff [kind]. How could
Sie solch einer Frau solch eine Unhöflichkeit sagen?
you say so rude a thing to such a woman?
Solch ein Tag ist schrecklich. Solch einem Künstler
Such a day is terrible. To such an artist
muß man solch einen Irrtum verzeihen.
one must forgive such a mistake.

(*b*). Rearrange the following sentences by putting the demonstrative pronoun *before* the indefinite article:

Ein solcher Skandal' wegen einer solchen Klei'nigkeit!
Such a scandal on account of such a trifle!
Eines solchen Mannes Pflicht ist Großmut; einem solchen
Such a man's duty is generosity; in face of such
Un'glück gegenü'ber ist der Mensch wehrlos; einen solchen
a misfortune man is helpless; such a
Fall habe ich in einer solchen Familie noch nicht erlebt!
case I have never experienced with such a family!

Key to Exercises [Page 2235]

Exercise 1. Ich beeile mich; er beeilt sich; du liebst dich; wir retten uns; ich sagte mir; Sie sagten sich; ihr sagtet euch; sie fürchteten sich; ich hatte mir gesagt; wir hatten uns ruinirt; er würde sich getötet haben; sie unterhält sich; wir unterhielten uns; schämen Sie sich! rasiere dich!

Exercise 2. Ich habe einundzwanzig Karten; er gab mir zweihunderteinundsechzig Pfund für das Jahr tausend neunhundert und eins; der Lehrer unterrichtet zweiundvierzig Knaben und siebenundfünfzig Mädchen, zusammen neunundneunzig Kinder. Im russisch-japanischen Kriege wurden zweihundertsiebenundvierzigtausend fünfhundert und achtundneunzig Soldaten verwundet — hundertfünfundvierzigtausend vierhundert und siebenunddreißig Russen und hundertzweitausend einhundert und zweiundfünfzig Japaner. Wie viel ist neunzehn und dreizehn? zweiunddreißig; vierzehn und neun? dreiundzwanzig. Einer von euch hat es genommen. Ich glaube es war der eine von den fünf Soldaten; er war der Vater zweier Söhne; er war der Vater von zwei Söhnen.

Continued

Preparation of Hat Brims for Fancy Linings. Velvet Binds and Crossway Folds. Preparing and Joining the Material. Making and Sewing in Bandeaux.

HOW TO LINE HAT BRIMS

DIFFERENT kinds of binds may be used to make brims more becoming to the face of the wearer, and also to form part of the trimming of the hat. Before a rouleau, velvet bind, or French fold can be sewn to the hat, the brim must be prepared.

Remove the wire already on the hat, as it is generally too thick and will cause the rouleau to stand out from the brim too much; and, secondly, it is very often of inferior quality, and is sewn on with stitches so far apart that it does not answer the purpose for which it is required—that is, to keep the brim in shape. A strong fine silk support wire to match the straw or felt is substituted, and, in the case of a straw hat, is sewn on the width of one straw in from the edge.

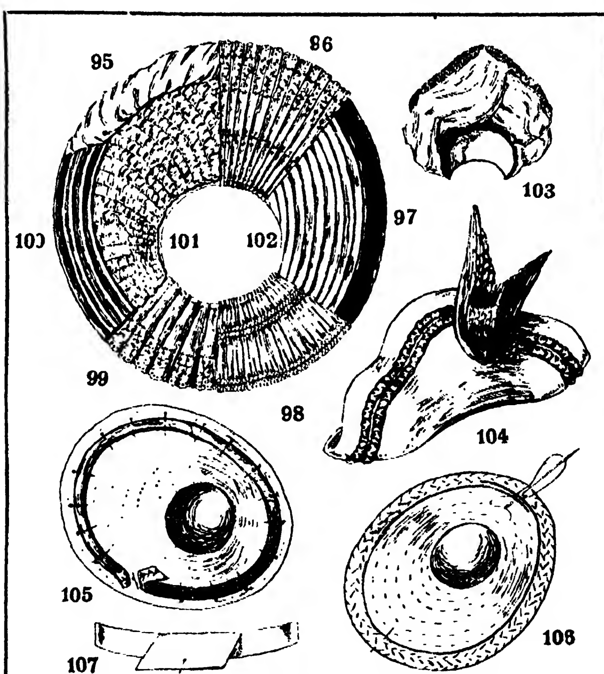
With open fancy straw it must be sewn on the part sufficiently strong to hold the stitches. Use wire stitch, and allow 2 in. on the wire to cross at the back [106]. The stitches must exactly fit the wire, and not be too far apart, or the wire will not set well round the curves. Contract the wire slightly for a turned-up brim.

Pin on the rouleau with lillikins, or steel pins, over the wire [105], stretch it slightly, cut away what is not wanted, allowing ½ in. for turnings for the join. Undo the fold for a few inches on either side, and join on the cross [114].

If there is already a join in the rouleau, see that the joins slant in the same direction, and herringbone the edges together again. Pin in place and slipstitch it to the hat just above the wire all round. The rouleau should lie quite flat, and no stitches must show on the right side. Felt hats are prepared in the same way, except that in smooth felts the stitches must not be taken through the brim, but only through half the thickness of the felt. Use a very fine needle and cotton. Felt hats are often wired at the edge, mulled, and trimmed with a velvet, silk, or braid bind.

Velvet Binds. For a velvet bind [97], measure round the edge of the brim. Most brims require one and a half to nearly two crossway lengths of velvet about 3 in. wide. Shade and join the velvet. Pin it on the hat and join in a round. Press the seams. The joins are very difficult to manipulate and show the difference between amateur and professional workmanship.

Stitch it in on the outside of the hat with long backstitch, the right side of velvet to upper side of brim. Turn over carefully and turn in the raw edge with the needle—on no account use the fingers, which would stretch the edge of the velvet. In boat-shape, French sailor, or similar turned-up brims, the bind, if carefully put on, will keep in place on the outside without any other stitching. For curved or fluted brims, the bind must be slipstitched on the underside, in order to set it in the curves. A corded or plain ribbon bind to a felt hat is evenly stitched with twist, the same size stitch showing on both sides of the brim.



95–107. HAT-BRIM LININGS

Another effective way of trimming the edge of the upper and under brims is by narrow crossway folds in velvet or silk [100], the fold of each row overlapping the raw edges of the previous one, the last being finished with a rouleau or French fold.

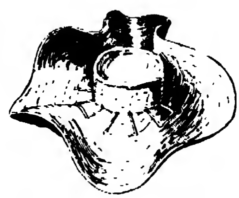
For a wide velvet or silk bind of 1 in. or more wide, on either side of the brim, measure round the edge, join the material in a circle, and press the seams.

Fold the velvet in the centre, stretch the centre of the fold with the blunt end of the scissors; be very careful only to stretch the *centre*—not the cut edges. Place this on the

edge of hat, turn in the raw edges, and slipstitch top and bottom, being careful not to draw the velvet.

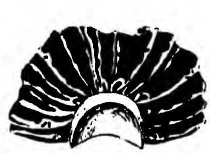
Full gathered or rucked edges on hat brims in either velvet or silk are made of crossway pieces, in length twice and a half times the circumference of hat, and about 3 in. wide. Join them in a circle, mark the half and quarters also on the hat brim. Regulate the fulness evenly, and secure the material by the long backstitch to the brim, along the gathering thread. Turn over the velvet and slipstitch down to underside of brim.

A much softer effect is obtained by not pulling the fulness tightly over the edge; also by regulating the fulness *diagonally* over the edge before slipstitching it to the under brim [95].



108. WIRING "FLOP" BRIMS

A cord run in a velvet tuck at the edge of velvet, drawn up to size of edge of hat, sewn on, the underside turned in and slipstitched as explained before, is another pretty finish [104].



109. VELVET BONNET LINING

Satin wires used on felt, velvet, or straw hats are slipstitched to hat brim, the stitches taken through the underside of silk filament of the wire, to prevent them showing when the hat is worn, and through half the thickness of brim in felt.

For joining at the back, side, or wherever the trimming is likely to come, carefully undo the silk filament at each end; cut away some of the cotton covering which is underneath, overlap the two wires for 2 in., twist the cotton covering round them, and wind round the silk filament again very gently. If carefully done, the join will be invisible. If two wires are to be placed very close to one another, there is no need to finish each round; the first one may be taken on to the next.

Crossway folds of silk or chiffon [102] for hat brims are cut 2 in. wide and joined in one length. Tack the edges together. Straw, felt, and velvet brims must first have a facing of mull, leno, or silk. Start from the outside edge, avoiding any joins showing in front of brim. Arrange each fold separately, *slightly* stretching the outside edge. Stitch each row in position, hiding the stitches of the previous ones.

Chiffon Linings. Gauged chiffon linings [98] take from three to four and a half times the circumference of brim; of fine tulle even six times, and the depth, plus as many tucks as required, is not too much to obtain a good effect.

Mark the half and quarter of the length, run three or more tucks at the edge; pin, and sew on hat just above the wire. Make more tucks, regulating the distance according to the shape of hat brim. Pleat evenly in the headlines.

Plain tucked chiffon linings are made with the tucks about $\frac{1}{8}$ in. to $\frac{1}{4}$ in. wide, each just overlapping the other. The tucks are usually run selvedge way, but they may be made on the cross. Slipstitch round the edge of brim and gather the fulness in the headline. Chiffon or silk may be gauged diagonally [101]. Draw up the gathering threads. Ease on round edge of brim. Cut the silk on the cross one and three-quarters the depth of brim, and one and a half times the circumference.

Pleated lace linings [96] have a tiny stitch taken *on* each pleat.

Fluted lace linings [99] have a tiny stitch between each pleat, and the lace is pleated evenly in the headline.

Beads are sometimes used as trimmings. They are threaded on fine wire and sewn on with a stitch taken through the bead into the shape. The wire should be held firmly with the left hand.

Soft felt, straw flop, or capeline hats [108] are wired round the edge. These shapes also need four extra wires to give support to the brim and crown. The wire is run for about $1\frac{1}{2}$ in. to 2 in. in crown. These are also wired round headline, or a band of net or buckram wired top and bottom may be used. For deep crowns, a separate wire foundation must be made.

The wiring of brim is done either underneath or on the top, according to whether the brim is to be turned up from the face or not. If wired on the outside, the trimming will in most cases cover it.

Bonnet Shapes. Nearly all bonnets have full or rucked edges which make a becoming front trimming for the face. There are two kinds, either for the open front or the close-fitting bonnet.

For the open front [109] a full velvet lining is often necessary to fill up the space between the bonnet front and the head.

For the close shape [103] a rucked edge is used to take away the hardness of the shape.

For the open front, measure the depth of the centre-brim and allow half as much again for fulness. Measure the outside edge of brim and allow half to three-quarters as much again for fulness.

If one length of velvet is insufficient, add on narrow pieces each side, as a bonnet brim is always much narrower near the ears. If a longer piece is necessary, join the piece on either side and cut afterwards in the middle of the narrow part [107]. Mark centre-front and gather each edge. Prepare the bonnet edge in the same way as the hat brim is prepared for a fold.

Place centre of velvet lining to centre of brim. Arrange most of the fulness in centre-front, lessening it gradually towards the ears. Backstitch the velvet on closely, just above the edge wire on the line of running stitches. The lower edge is stitched round the head and the velvet arranged in light puffs with the point of the needle.

For a "rucked edge," the measuring, cutting off, and preparation of velvet are the same as just explained, the only difference being that the velvet is not usually stitched on the edge of the bonnet, but about 1 in. to 2 in. *above* it.

The needle should never be put through the double pleat of the velvet; it should be brought back close to where it went in and the cotton tied. Lightness of touch, to use no more stitches than necessary, and never to draw the fulness tightly over the edge, are points to be remembered. The bonnet should next be headlined.

Preparing the Velvet. Velvet is a rich-looking fabric whose chief characteristic is its *pile*, or raised surface. It has a short surface which, in coming from the loom, is pressed slightly in one direction, thus casting a shade, and giving it a darker tone against the pile than with it. Experienced fingers can feel the way the pile lies, it being smoother in one direction than the other. The better the quality of the velvet, the more distinct is the shade. In correct shading lies much of the difference between amateur and professional work. Hold the velvet to the light, and, before joining or cutting out, see that the pieces shade the same way.

Three kinds of velvet are in general use—the silk, the patent, and the cotton back. Velveteen is too heavy, and is used only occasionally to match children's Liberty coats and pelisses. The silk-back velvet is manufactured entirely of silk filaments; it is very light, has a close pile, keeps its colour to the last, renovates well, and is always used for the best class of work. Its price is from 7s. 11d. a yard. It wants careful manipulation, as the lightness of its pile causes it to be easily plushed or flattened.

The "patent-back" velvet is a mixture of cotton and silk, but it is easily distinguished by its highly-glazed back. In the best qualities it can be mistaken for silk velvet. Its price is from 3s. 11d. upwards. It is much in use and can be obtained in a wide range of colours.

In cotton-back velvet, as its name implies, the pile alone is of silk. It is of much more open texture, soon fades, and is heavier to wear. It is only used for very cheap millinery, and costs from 1s. 11d. Miroir velvet, of the same quality, has a much better appearance because the pile is flattened down uniformly and prevents the foundation showing through the pile.

Several other kinds of velvets are used, such as panne, chiffon velours, terry, caracul, shot, plissé, corduroy; but these are only passing fashions, and their use for trimmings or coverings at once dates a hat or bonnet.

If required for trimmings only, buy the velvet on the *cross*. For covering hats it should be bought on the straight. A *corner of velvet* is extremely useful for toques or bonnets.

If we have a length of velvet on the straight, before we can cut crossway widths for trimmings, a corner must be cut off. Place the velvet on the table with its pile uppermost, and the fold *from you*—this is important. Fold the two faces of the pile together when they will not want pinning. Take the right-hand lower corner, A, of the cut edges to the selvedge of the opposite side, B. The two selvedges must be exactly at right angles. Then cut through this fold. Any length corner can be obtained by folding the velvet as from C to D instead of from A to B [110]. The extra length obtained along the top is short at lower edge [111].

A corner of velvet, it will be seen, is a shaped piece with one side on the straight and one on the cross. In covering and trimming bonnets and toques pieces can be cut from the crossway side for the trimmings, while the corner and straight part are used for covering or draping the bonnet or crown.

To cut a crossway width [112], measure the length required first along one selvedge and then along the other; snip the velvet at those points; fold it over—from you—and cut off. Be very careful that the velvet is really cut on a true cross; if there is the least inaccuracy the folds, rouleau, or trimming will not lie well and the material will be wasted.

A crossway length will measure one-third less *through the centre* than along the selvedge, and allowance must be made for this when estimating quantity required. By "through" is meant through the cross—as opposed to along the selvedge. This should be noted as the word will be so employed throughout this course.

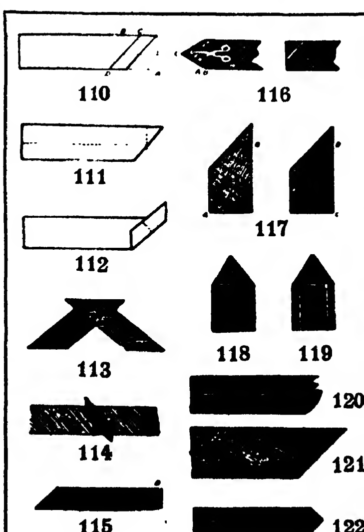
Joining Velvet. To join velvet [113] shade the velvet correctly, place the two piles together, leaving a little triangle at each edge [114]. Backstitch them with fine cotton and needle—the stitches must be quite close and tight so that there may be no gaping when stretched.

To straighten two crossway lengths for trimming, shade the pieces and join. Cut off a corner [115] and join it to A B.

To straighten one crossway end, fold A to B, stitch it and cut [116].

Trimmings and bows are frequently made of crossway widths of piece velvet. After joining the length, the raw edges must be hemmed, which can be done either by turning in the edge once, as for twists, knots, etc., or turning in the edges twice for the loops and bows, and making a narrow roll hem. In the latter case a fine wire may be inserted in the hem.

Ends of crossway pieces can be used up in making ends and ears. Ends, if faced with velvet, must be stitched along



110-122. PREPARATION OF VELVET FOR TRIMMINGS

the straight side and slipstitched along the crossway side. They do not set well if not treated in this way. Pull out the point from the outside with a fine needle. In stitching do not pull the cotton tightly. Stitch as from A to B [117]; slipstitch from B to C. Always stitch for 1 in. round the point at B.

An ear is made by the long point being turned back pile to pile and stitched [118]. Turn out and hem along bottom edge. For unlined ends and ears the edges must first be roll hemmed [119]. Ends and ears may be lined with a contrasting colour of velvet or silk, joined in the same manner as described above. How to wire ends and ears is dealt with later.

For a velvet fold or rouleau, cut crossways a piece twice as wide as required, turn down each side, so that the cut edges just meet in the centre, and lace-stitch the two edges together. Another method is to slightly overlap the edges and hem as for velvet. Do not cut the rouleau too wide or it will not set well.

For a French fold [120], cut material three times the width of the required fold. Fold it in three, one cut edge inside and one outside. Turn down the outside edge and slipstitch it, begin careful the fold does not become twisted.

Velvet Bonnet Strings. Ladies sometimes prefer piece velvet bonnet strings to ribbon, because it may be impossible to obtain ribbon velvet to match, and they are warmer to wear, and more becoming.

Cut three times the width required when finished. Usually two widths 2 in. "through" are needed. Shade the pieces and join. Make a cravat end [121], and slipstitch as for French fold. Place the fold exactly opposite to the point of the cravat end. The strings should be about ⅝ in. wide when finished.

Another way is to hem a long piece of cross-cut velvet, make the ends up in bows, and tie under the chin. The width is a little narrower than the ⅞ in. ribbon velvet usually sold for bonnet strings because it is thicker. Piece velvet bows are made of velvet cut on the cross. The widths should be joined in one long length, and the edges roll hemmed.

Bandeaux. The style and fit of a hat depend frequently on the right shape of the bandeau, which gives it the proper tilt on the head. When it is made, pin it in, trying different positions till the right one is obtained. Often a hat does not suit because it needs a bandeau, or because the bandeau is in the wrong place.

Bandeaux vary in size and shape, and are usually covered with velvet, which clings to the hair and helps to fit the hat. They are used for these purposes: To tilt a hat at front, side or back; for sewing trimmings underneath; or to make a faulty headline either larger or smaller.

In form they are either *shaped*, *round*, or *straight*. Shaped bandeaux for front, side, or back, are made of spatric or buckram; for light hats, such as chiffon, lace, tulle, of double stiff net. Round and straight bandeaux are made of stiff net and ribbon wire.

First cut out the shape in buckram and wire it with firm support wire [124]. Start wiring in the centre of the straight side of the bandeau and allow 2 in. for overlapping.

Mull the edge. Cover it with a crossway piece of velvet, placing the straight side of bandeau to crossway part of velvet [123]. Pin it in place. Cut to shape, leaving ½ in. turnings round curved part. Turn in and slipstitch, cutting the bandeau in shape as it is worked.

Bandeaux for back of hat [125] must be covered in two parts. Cut the velvet to shape, leaving ½-in. turnings. Tack one piece, turning the edge over all round, and catch-stitch it to the spatric. Pin on the other piece of velvet, turn in the edge, and slip-stitch all round.

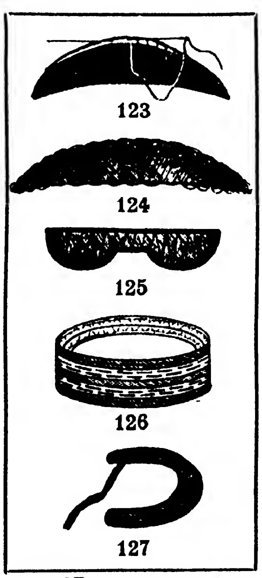
Net bandeaux for light lace, net, chiffon, etc., hats are made of double stiff net, wired all round, with support wires inserted between the two thicknesses of net, and nipped securely over the edge. These are covered with one or two thicknesses of tulle or chiffon, and bound with sarcenet or narrow velvet ribbon [127].

Shaped, all-round bandeaux are made of support wire to given measurements in the same way as wire shapes are made. These may be covered with straw or velvet, and, for a very deep shape, only the outer side need be covered.

Round bandeaux [126], used for reducing size of headline, should be made in this way: cut four thicknesses of stiff net, about 1 in. wide, and in length ½ in. smaller than headline; allow 1 in. extra for overlapping. Stitch two rows of ribbon wire to the net, wrapping over the ends of wires 1 in. where they join. Cut a crossway piece of velvet three times the width of the net bandeau. Turn in upper edge of velvet, bring up the bottom side with the raw edge turned in, and slip stitch.

A straight bandeau is made in the same way, except that the ends are not joined. Turn over ribbon wire for ¾ in. each end. Cover with velvet, oversewing the raw edges closely, without turning them in.

"Chip" bandeaux are mostly used for fronts of open-fronted bonnets, and are made about 11 in. long, wired all round. Stretch the chip along the outer edge and contract along the bottom edge. At each end, turn it into half its width.



123–127. HAT BANDEAUX

To sew the bandeau to hat, pin it in the right position Use strong cotton and the long backstitch, keeping the long stitches on the outside of the bandeau. Catch the bottom wire of bandeau to the headline or brim of hat.

Cast-iron Pipes. Pipe Founding. Butt and Lap Welded Tubes. Seamless Tubes and their Manufacture by Various Processes.

TUBE MANUFACTURE

INTO how many articles of domestic, industrial, and public utility does tubing enter? We do not intend to supply the answer, for we cannot, but the question may cause the reader to look around him, and he will be surprised at the innumerable uses of tubing. The first use of metal tubing was for the manufacture of gun-barrels. The need for cheaper tubing than gun-barrels provided came with insistence during the early years of last century. The introduction of gas lighting called for very large quantities of tubing, and at first the need was met by old gun-barrels, of which there was a plethora after Napoleon had been finally housed in the island where he died. Then with the need for cheaper tubing came invention, and the files of the Patent Office contain the records of very many attempts to solve the problem of tube manufacture, each vieing with each in efforts after economy and quality in tube production. But we have to do with the practical, not with the historical, side of the question, and we may proceed to examine modern processes of tube manufacture.

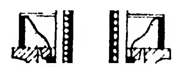
The word *tube*, or *tubing*, and the word *pipe* have the same meaning, and have been defined as "anything hollow or concave, and with some degree of length." The definition is comprehensive, and would include a nut or a washer. But length is the conspicuous feature of a tube, and anything so short as a nut or a washer would not come under the definition of a tube, although technically both of these articles are short tubes. The word "pipe" is usually applied to tubes of cast iron, and also to those of lead, but tubes of wrot iron or steel and of metals other than lead are usually designated by the word "tube." The difference is merely a matter of habit, and has become fixed. It is convenient, because to talk of an iron pipe is accepted as meaning something of cast iron, and an iron tube implies something of wrought iron.

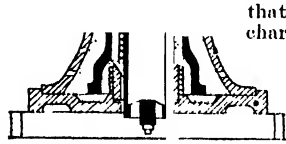
Cast-iron Pipes. The chief use of cast-iron pipes is for water and gas mains. The usual length in sizes under 3 in. internal diameter is 6 ft., and for larger diameter pipes the length is usually 9 ft. American practice favours 12 ft. lengths for large water pipes, and there is economy in the longer length as there is then occasion for fewer joints.

Iron pipes are usually cast in a vertical position, and usually also with the socket end at the bottom. The practice is not universal, for small pipes are often cast in the reverse position, but the desirability for strength in the socket part constitutes a reason for this method of procedure.

Cast-iron pipes are largely made by dry-sand moulding, which is the best and cheapest process where the metal is poured under any great head of pressure. This process of moulding does not demand so much skill as greensand or loam moulding, and consequently it produces cheaper work. Indeed, skilled labour is almost dispensed with in pipe founding. In the most improved practice the casting pits fill the purpose of core ovens as well. This utilises the heat left from the casting. When being used as ovens the pits are covered and flues admit the hot air.

The Moulding-box. The moulding-box [1] is made in two halves, and has a hinge joint, enabling it to be opened longitudinally. It is provided with perforations for the escape of gases as the metal is being poured, and also as the moulds are drying. The size of the moulding-box is sufficient to allow about 2 in. of sand between it and the pattern. Its base is made separate from the main shell, and before the moulding-box body is placed upon the base a cast-iron pattern of the socket is clamped into its place. Then the moulding-box or flask is placed upon its base and clamped thereto, the cast-iron pattern for the pipe-barrel is put into position inside it, the space between the pattern and the flask is filled with sand and rammed hard with long rods, and the pattern is withdrawn. The surface of the mould is now blackened. A common practice is to pour black-wash—that is, finely-powdered charcoal made with water into the consistency of cream—into it, care being taken that it gets around all the surface. The mould is then dried.





1. MOULD FOR CASTING PIPES

The moulding-boxes, after ramming, are placed over apertures, which are exhaust flues. The heated air entering the pit or oven—for in this capacity it is being used—passes up round the exteriors of the moulding-boxes and descends through the mould to the exhaust. After the moulds are dry the moulding-boxes or flasks are set in position for the pouring.

Preparing the Core. The core ought to be ready for insertion at this stage. Its preparation has been simple. Upon a long shaft, or arbor, is wound tightly a course of straw or hay rope of about ¾-in. diameter. This is done by placing the shaft or core bar upon trestles with grooves, in which the bar may rest, and by turning it with a handle fitted to its end. When one layer of rope has been put on, soft loam is applied and rubbed in between the spirals of rope throughout the whole length: then another course of rope is wound on, and more loam applied until the internal diameter of the pipe to be cast is reached. A loam board or *strickle-board*—that is, a templet the form of the edge of the longitudinal section of the desired core—is used to give it shape. The core may be partially dried during the process, otherwise the mass of loam and core rope would not be sufficiently cohesive to remain unbroken. It will also probably be bound with iron wire for the same reason. Then it has a last coating of sifted loam, sometimes mixed with sawdust, made thin with water, is "stricked," or made true to templet, and is finally dried. In pipe founding the core bar is

allowed to remain inside the core in the mould so as to give it strength, as a long core is necessarily weak. The core must have a diameter slightly larger than the internal diameter of the pipe desired, as the iron shrinks in cooling, the approximate shrinkage and the usual practical allowance being ⅛ in. to every foot of diameter.

The cores made as described are treated to blackwash, as was the mould, and are then inserted within the mould.

The socket core is wrapped with hay rope and plastered with loam in the same way as the centre core, being also stricked by a templet and dried in the manner already described.

Collapsible iron bars have been tried instead of rope cores, as the latter are an expensive item in pipe founding, but they have not come into general use.

Casting a Pipe. The molten metal is usually poured from the top of the moulding-box, but sometimes large pipes have as much metal as will cover the socket-core poured from the bottom by a gate through the mould to the socket, the metal for the body of the pipe being poured from the top in the usual way. By this method there is less danger of injuring the socket-core by the heavy drop of metal upon it, but it gives the possibility of a "cold shut" between the metals of the two pourings.

Whenever the iron has set, the core bar is withdrawn by means of the crane, so as to prevent any danger of the pipe cracking as it cools, and the straw that is left at once begins to burn. When the pipe has dulled down to black, the shell of the moulding-box containing the pipe is hoisted up and placed over skids, where it is opened and the pipe rolled out upon the skids.

Flanged pipes are made in practically the same way, but it is a common practice to have a separate moulding-box for the lower flange and to clamp it on the cylindrical moulding-box used for the pipe body, the upper flange being made with a templet attached to a ring revolving on a pivot on the pattern, and a space being left for the cover.

Pipe Sizes and Weights. Cast-iron pipes are made from ⅜-in. thick to 1¼-in. thick, and the following table gives the range of thicknesses in which the various sizes are made with the weight of each per lineal foot.

Dr. Angus Smith's solution is in very wide use for coating pipes that are to be laid underground. It gives the pipes a coating impenetrable to the liquid or other matters that usually pass through drain and water pipes, and it prevents corrosion. The original recipe took 60 gallons of coal tar, 60 lb. of freshly slaked lime, 12 lb. of tallow, 6 lb. of lampblack and 3 lb. of resin, all mixed together, boiled for half an hour, and applied hot. Present-day practice has departed from this, and there is not strict uniformity. A good method, largely followed, is to put coal-tar in a dipping tank large enough to accommodate the pipe to be treated, then to add one-seventh part by volume of pitch in powder form, and one-seventh part of coal oil. The pipes are heated to just under boiling point, say 200° F., and are placed into the mixture, turned over for a few minutes, and then withdrawn and allowed to drain.

Welded Tubes. Many improvements have been made in the processes of tube manufacture during the last fifty years. These have been chiefly in the making of seamless tubes. Welded tubes are made practically as they were made three-quarters of a century ago. There may be slight difference in the details of the process, but the principle has not been changed.

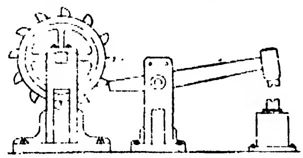
Welded tubes may be divided into two classes—*butt-welded* and *lap-welded*. In both cases a strip of flat metal is bent round into tubular form by special apparatus. Butt-welded tubes are those where the bending of the strip causes the two edges to *butt* or touch each other, and in this position they are welded. Lap-welded tubes, on the other hand, are bent round so that the two edges overlap, and in this position they are united by welding. A lap-welded tube must have a mandrel or solid rod inside when it is being welded, but a butt-welded tube can be welded without internal support during the process. Thus, very small tubes can be made butt-welded, but not lap-welded. Butt-welded tubes of iron are made as small as ⅛ in. internal diameter, and they could be made even smaller, but the minimum internal diameter of lap-welded tubes is considered to be about 1 in. The manufacturer of welded tubing purchases "rolled strip" from the iron-rolling mills. This rolled strip is simply iron hoop or plate in the form of strips of the width necessary for the tubes about to be made. He converts this strip into "skelp," or tubes, the edges of which touch or overlap, but are not welded together. This is done by passing the strips through rolls, which first curve it and then bend it round until the edges touch or overlap.

Formerly, the tilt hammer process [2], patented eighty years ago by James Russell, of Wednesbury, was the common practice, and may still be followed to some extent. By this process the roughly-formed tube was heated to welding heat and passed along the grooved anvil of a tilt hammer, caused to strike rapid blows by the rotation of a wheel with projections as seen in the illustration. A mandrel was placed inside the tube being welded, if exactness in the internal diameter was desired, but if such exactness was immaterial, no mandrel was used. The invention of this process was an important stage in the development of tube manufacture, as it proved that a rough tube heated to welding temperature could be welded up merely by having its edges placed in contact and pressure applied, and without the need for the employment of an internal mandrel such as had been previously used.

WEIGHT OF CAST-IRON PIPES IN POUNDS PER FOOT

Bore in Inches	Thickness of Metal in Inches							
	⅜	½	⅝	¾	⅞	1	1⅛	1¼
2	8·7	12·3						
3	12·4	17·1	22·2					
4	16·1	22·1	28·3					
5	19·8	26·9	34·4	42·3				
6	23·4	31·9	40·6	49·7				
7	27·1	36·8	46·7	56·8				
8	30·8	41·6	52·8	64·3				
9	34·4	46·0	58·9	71·7				
10		51·4	65·1	79·0	93·3			
11		56·4	71·0	86·4	102·0			
12			77·3	93·7	110·4	127·4		
14			89·6	108·4	127·5	147·0		
15				115·7	136·1	156·8	177·7	
16				123·1	144·7	166·6	188·7	
18				140·0	161·8	186·2	210·8	
20					178·9	205·8	232·9	260·3
22						225·4	254·9	285·0
24						245·0	277·0	309·4

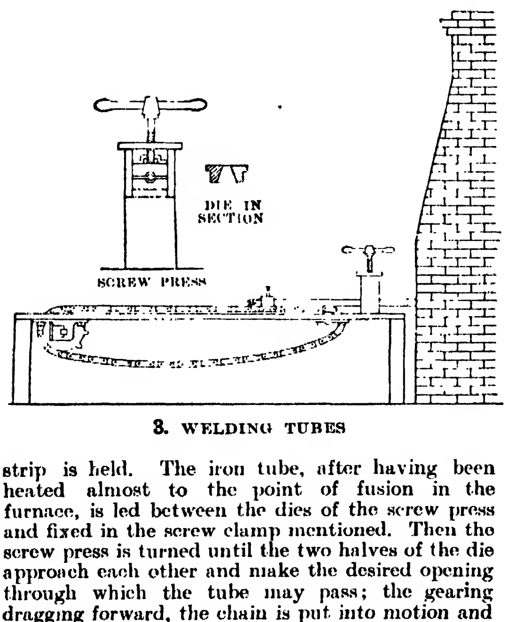
During the year after Russell began to exploit his patent, Whitehouse, of Wednesbury, introduced his draw-bench process, which is that still used, and which is best described in the words of the original specification (No. 5109, of 1825).



2. RUSSELL'S PROCESS FOR WELDING TUBES

"I prepare a piece of flat iron, commonly called plough-plate iron, of a suitable substance and width, according to the intended calibre of the tube. This piece of flat iron is prepared for welding by being bent up on the sides, or, as it is commonly termed, turned over, the edges meeting, or nearly so, and the piece assuming the form of a long, cylindrical tube. This tube is then put into a hollow fire, heated by a blast, and when the iron is upon the point of fusion, it is to be drawn out of the furnace by means of a chain attached to a draw-bench [3], and passed through a pair of dies of the size required, by which means the edges of the iron will become welded together."

He then describes the mechanism. The chain, which is driven forward by a spur wheel, carries a screw clamp in which the end of the metal



3. WELDING TUBES

strip is held. The iron tube, after having been heated almost to the point of fusion in the furnace, is led between the dies of the screw press and fixed in the screw clamp mentioned. Then the screw press is turned until the two halves of the die approach each other and make the desired opening through which the tube may pass; the gearing dragging forward, the chain is put into motion and the bent strip, entering the screw press dies, emerges from them in the form of a welded tube. It is withdrawn from the clamp and from the screw press. A small length of tube at the end where the chain clamp is attached is not welded. This piece is welded by returning that end to the furnace and, when it has been made white hot, by drawing it through the dies from the other end.

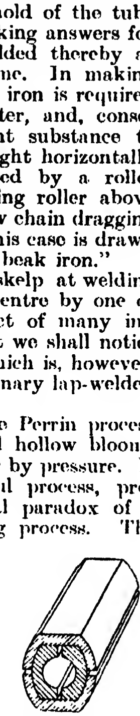
Sometimes the edges of the strips used for making butt-welded tubes are cut obliquely, making the weld thereby not a true butt, but a sort of lap. This practice makes a slightly better tube than the plain butt weld, but is still much inferior to the lap-welded tube, which we shall now consider.

Lap-welded Tubes. In its essentials the process of welding tubes with a lap weld is similar to that employed for butt-welded tubes except that a mandrel must be used to afford the necessary resistance during the operation of welding, as the pressure must be applied in a different direction to that when the weld is of the butt variety. Russell's original process (1845) which is that still usually practised, is described by its author as follows:

"The tubular skelp drawn from the furnace at a welding heat is placed upon a mandrel or what the inventor terms a 'beak iron,' which has a working surface of steel and is rigidly fixed at one end in a horizontal position, its free end projecting over a draw bench. The free end of this beak iron affords the necessary resistance and support when the lap joint of the tube, in order to weld it, is pressed upon by a roller while the tube is drawn off the beak iron by the action of the draw chain to which the grippers that have hold of the tube are attached. This system of working answers for tubes of large size, which are welded thereby at two operations, one half at a time. In making smaller tubes the mandrel or beak iron is required to be longer and of small diameter, and, consequently, as there is not sufficient substance to support the tube and its own weight horizontally without deflection, it is supported by a roller beneath the tube while the welding roller above is operating on the seam, the draw chain dragging the tube forward. The skelp in this case is drawn direct from the furnace on to the beak iron."

This process, that of rolling the skelp at welding heat and with a mandrel in the centre by one or more rollers, has been the subject of many improvements, but the only one that we shall notice separately is the Perrin process, which is, however, rather beyond the scope of an ordinary lap-welded tube.

The Perrin Process. The Perrin process of manufacturing tubes uses piled hollow blooms placed as in **4**, and welded together by pressure. It is an important and a successful process, producing the apparently mechanical paradox of a seamless tube made by a welding process. The blooms are rolled into channel sections, and are placed as shown in the diagram. The edges must not butt where one channel section opposes a similar channel. This leaves room for compression, and a thorough weld between the external surfaces of the inner pair and the internal surfaces of the larger pair. When the piled blooms have been raised to a welding temperature the pressure of the uppermost outer bar upon the inner bars and the pressure of the inner bars upon the lower outer bar cause the parts to become united or partially welded along their adjoining circumferential surfaces, and by such welding before removal from the furnace the bars are retained in their proper relative positions during the subsequent rolling operation, which completes the welding. The piled bloom is rolled down at one heat sufficiently thin to form some sizes of gas, water, steam, or other tube.



4. PERRIN'S PROCESS OF TUBE MANUFACTURE

Spirally Welded Tubing. Spirally welded tubing is made and used to some extent. It is specially suitable for large tubes that have to stand high pressures. The spiral welds withstand bursting strains far above longitudinal welds. Another feature of merit is that this tube can be

made in very long lengths. Also spirally welded tubing that leaks at low pressures tends to become tight as the pressure increases, and to remain so. This property may seem curious, but it may be put to the proof. If we make a twisted paper tube, close one end, and blow into the other end of it gently, the air we send in escapes at the edges of the spirals, but if we blow into it with more vigour, the tube becomes tight. Thus, internal pressure on a spirally welded tube tends to force the overlapping edges of the spirals into closer contact, and to make the welded surfaces tighter, whereas internal pressure in a longitudinally welded tube tends to open the weld and to force the edges apart.

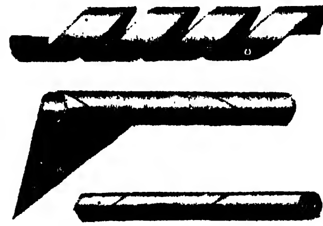
Making Spirally Welded Tubing. The process of manufacturing spirally welded tubing demands very accurate machinery. It is almost quite automatic, and does not entail highly skilled labour. The skill has been put into the machine. The "stock," or iron or steel plate, is rolled of the required width, and in as long strips as possible. The ends of these strips are welded together in a machine so as to give any desired length of strip in one piece. The completed strip or ribbon passes to the tube-making machine, which has four functions—feeding, bending, heating, and hammering. The end of the ribbon of metal is fixed to a guide table, set to the angle of the spiral, and is fed in by geared rollers. A mandrel is not employed but the mould is of a form to keep the size and alignment accurate. Projecting into the pipe, a distance a little in excess of the width of the skelp or stock used, is an anvil, cooled by water circulation and protected by firebrick. The furnace which raises the edges to welding heat is a small cast-iron box, lined with refractory material containing two nozzles, which are really blow-pipes, extruding a Bunsen flame upon the edges to be welded. One of these blow-pipes heats the edge of the pipe already formed, and the other heats the part of the skelp that is to be welded to it. The entering skelp meets the hot edge of the pipe just where the two flames from the blow-pipes meet; a hammer, with rapid blows, welds the two edges as they pass across the face of the anvil, the crimper also acting upon the work to preserve the proper curvature, and the pipe is made. The machine, acting as we have described, makes a foot of welded surface per minute.

Flanges of Spirally Welded Tubes. Spirally welded pipes are usually flanged, as this is the best way of joining them one to the other. The type of flange is what is known as the trumpet flange. The end of the pipe itself is turned over flat, thereby forming a narrow flange. The larger flange comes behind this, and has holes for bolts, so that two flanges are tightly pressed one against the other. But the strength of the union depends not at all upon the union of the large flange to the pipe, for the large flanges merely press the smaller flanges tightly together. Packing is, of course, used.

Spirally welded pipes have been made up to about 50 ft. long, but such lengths are convenient only when they are to be used close to the place of manufacture, because about 30 ft. is the longest that can be transported without the creation of exceptional facilities.

Spiral tubes, with the spirals united to each other by riveting instead of by welding, as described above, are also made to some extent, and their manufacture is cheaper than that of the spirally welded. Their chief economy is when they are of large size.

Helical Steel Tubing. Another form of spiral tubing is the so-called *helical tubing* [5] (Hillman's patent), used in the manufacture of Premier cycles. Long strips of sheet steel, usually of crucible cast-steel, is coiled round a mandrel, each spiral overlapping the preceding one to half of its width. The overlapping surfaces are then brazed together.



5. HELICAL TUBING

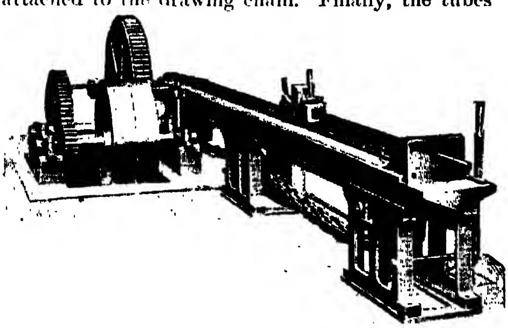
Seamless Tubing. Seamless steel tubing has many advantages over welded tubing, no matter what process of welding may be adopted. There are very many processes by which seamless steel tubing is manufactured. These processes follow one of three practices. First, there is the process of piercing the billet with a mandrel or drill, thereby making a short cylinder, to be afterwards rolled or drawn (or rolled and drawn) into the desired tube. Then there is the process whereby the billet is made with a core; and, finally, there is the wonderful Mannesmann process, whereby, under the action of rapidly revolving rollers of special construction, the solid billet is "spun" into tubular formation and attenuated to make the final tube. We shall look at these different processes in their order, selecting in the first two the main principles common to many adaptations of the process.

The manufacture of solid drawn tubes consists of two main operations—namely, rolling and drawing, the former being done while the metal is hot and the latter when it is cold. The material comes into the works in the form of billets, usually round, with a diameter of about 6 in. and a length depending upon the tube to be made, but usually from 18 in. to 24 in. The billets are, of course, solid, and the first process consists in drilling them with one hole up the centre longitudinally. Usually a special horizontal machine operating upon both ends of the billet simultaneously does this work. It is often done with the billet in a bath of water, which constitutes a lubricant for the drill and speeds up the work. The drilled billet is put into a furnace, and when it has been extracted hot, a hard steel mandrel is forced through the central hole to enlarge it. This is performed with the help of a hydraulic press.

Again the billet is heated, and the next process lengthens it, and it begins to assume a shape approximating to its final form. It is rolled between grooved rolls, while a mandrel is kept in position in the centre of the circular hole formed by the two grooves in opposing rollers. As the billet is passed through the rolls, it is forced on to this mandrel. It goes through this operation several times, each time having a smaller pair of grooves through which to pass. The mandrel over which it passes is shaped something like a bullrush, a head of the required thickness and a stem of thinner metal behind. Each pass of the tube through the grooves we have described forces it over the mandrel and on to the stem, whence it has to be removed to be passed through again until it is sufficiently drawn. With tubes of small diameter the bar or stem of the mandrel cannot be made sufficiently strong to withstand the resistance offered by the tube as it is being

forced on; so in this case the tube is first put on the mandrel stem and then drawn over the head through the grooved rollers. By this means the strain upon the mandrel stem is changed from one of compression to one of tension.

When the tube has been drawn hot in the manner described to a certain point, it is cut with a hot saw to length, and the finishing processes are performed cold. These finishing processes are: drawing through dies several times, and annealing and pickling between after pass. The machine used is the chain draw-bench [6], which we have already seen in use for making butt-welded tubes, but the test through which the tube passes is not a screw press, but a hardened steel die. Otherwise the operation is the same as we have already seen. The tube, as drawn cold, contains a mandrel, so as to preserve the true diameter, and each die being smaller than the external diameter of the tube as it enters, elongates the tube. The annealing furnaces must be large, as they have to accommodate tubes up to 25 ft. long. After annealing, the tubes are pickled in dilute sulphuric acid, to rid them of scale. Special hammers also are usually employed to reduce the ends of the tubes for gripping in the screw clamps attached to the drawing chain. Finally, the tubes



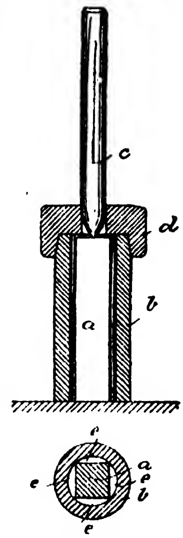
6. TUBE DRAW-BENCH

are cut by cold circular saws, and are ready for the market.

For very light gauges of tubing, such as used for cycles, the tubes are, after cold drawing, reduced further by a process of cold rolling. This operation is performed by means of two horizontal taper rolls placed side by side and tapering towards opposite directions. The tube, having inside it a mandrel fitting it exactly, is passed through these rolls, which stretch the metal, and can reduce a tube from 9 B.W.G. to 16 B.W.G.

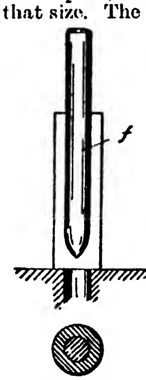
The Ehrhardt Process. In the process just described the billet is drilled when it is cold. It is also common practice to displace some of the metal from the centre of the billet when it is hot. One of the various methods may be adopted to this end. We shall describe briefly one such process. It is the Ehrhardt process, and is used in the manufacture of gun liners, shells and other war materials, as well as for making ordinary steel tubes. The process is as follows, in the words of the inventor's specification:

"To produce a hollow cylinder from wrought iron or steel, a piece of square iron or steel is taken, the cross-section of which, measured diagonally, corresponds to the diameter of the hollow cylinder to be pierced. The said piece of iron or steel [7*a*], when in a red-hot or white, glowing state, is delivered into the matrix *b*, the inner space of which also corresponds to the shape of the hollow cylinder to be produced, and a pointed core-bar, *c*, is then driven into the metal by means of a hammer or press, while the lid, *d*, is used as a guide for the said core-bar. The diameter of the latter is chosen so that the material forced aside by it is sufficient to fill the four segment-shaped spaces between the square sides of the block and the interior surface of the matrix. The core-bar enters the metal without any difficulty, as the metal, while being forced away, can give way at its sides, and a hollow cylinder with closed bottom is produced." The lower part of 7 shows a section of the square billet in the cylinder previous to the introduction of the core, and 8 shows the core, *f*, driven home, with a section showing how the billet is expanded to circular shape. The billet may be pierced from both ends as illustrated in 9.

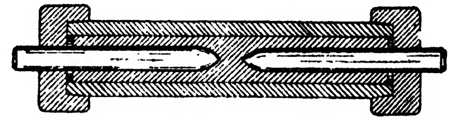


7. EHRHARDT PROCESS BEFORE PIERCING

This is the principle of the process, and we may make a brief examination of the practice. The billets used are generally of Swedish steel, and are received square, a shape which is an important essential. They are 10 ft. or 11 ft. long, and in section are from 3½ in. to 8 in. square. The billets are cut to lengths sufficient to allow sufficient metal for the pipe to be made. The cutting is done with cold saws when the sections are over 5½ in., and with hot saws when smaller than that size. The cut length at white heat is then put into a vertical hydraulic press provided with a circular die. The corners of the square billet just touch the internal circumference of the die, so that there are four segments between the die and the billet. A mandrel now descends and the billet is pierced, the metal displaced in making the hole causing the mass to expand and to fill the segments already mentioned. The mass of metal put into the die and the mandrel must be apportioned in size so that the metal displaced by the latter must exactly fill the cylindrical die at its circumference. The billet pierced in this manner is again heated, and taken to the draw-bench, where it is drawn to the required gauge. The same internal diameter is maintained from the piercing to the last drawing process, all the drawing processes reducing the external diameter by elongating the metal. When exactness of gauge and diameter is



8. EHRHARDT PROCESS AFTER PIERCING

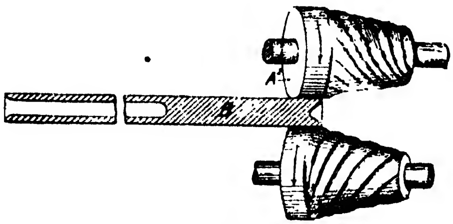


9. EHRHARDT PROCESS PIERCING FROM BOTH ENDS

not of first importance, pipes may be finished hot. When these considerations are matters of moment

the final processes are cold drawing, as described in the previous process, the tubes being pickled after the hot drawing and annealed and pickled after the cold drawing.

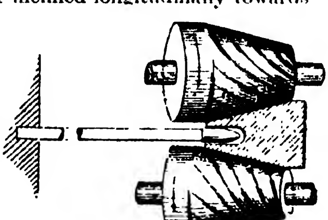
Tubes from Cored Billets. Several processes, by which the metal ingot from which a tube is made is produced with a longitudinal hole, thereby making it cylindrical in form, have been



10. MANNESMANN PROCESS

evolved and some are in operation. In one, the core is of oblong section and is, of course, made of some refractory material such as graphite. The billet, being cast with this core is flattened, making what is in effect a flattened tube. It is then opened and goes through several modifications of sectional form, ultimately becoming round and being drawn over mandrels in the usual way. Every process using billets already cored in their first state proceeds much after the same manner.

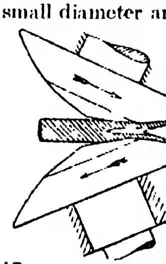
Mannesmann Tubes. The Mannesmann process of manufacturing tubes from steel ingots was described at its introduction in 1890 as "an epoch-making invention." The absolute novelty of the process and the marvellous results which it gave caused experts to be sanguine about the revolution it was to make in tube manufacture. To quote the words of one of the experts who hailed it with acclaim, it "accomplishes the apparent mechanical paradox of expanding a solid block of metal into a hollow steel tube with a void within several times its own original mass, by pressure applied from the outside, and this it does with great certainty, ease, and quickness." This is really what the process accomplishes. It must be stated, however, that the Mannesmann process has not killed every rival process, and to this extent it has disappointed the great expectations of its inventors and sponsors. It is one among many good processes, not the superlative process that has superseded all others. Its chief objection is that very great power is required for the machines necessary, and this means a high expense. Of the quality of the product there is no question. It was found that a red-hot billet led between two rapidly revolving rollers [10] of conical section or inclined longitudinally towards each other — revolving in the same direction— that is, with their opposing surfaces revolving in opposite directions, as indicated by the arrows in the illustration—was made to assume a hollow shape, of tubular form. What seems to be a vacuum is created. The space is, however, found to be filled with almost pure hydrogen gas given off by the hot iron. The heated billet is placed between



11. MANNESMANN PROCESS WITH MANDREL

the rolls, being led through guides, so as to make lateral motion of the rod or billet impossible. The end of the billet that enters the rolls is slightly flattened, and this causes the particles on and near the surface to be pushed forward more quickly than the remaining parts thereby forming a cup-like recess in the end of the billet. As the rolls keep moving, the hot metal is pulled from the inside of the rod and pushed forward in the shape of a tube. Great rapidity is essential, or the metal would become too cool for manipulation before reaching the end of the billet. As already stated, the power required for this process is very high. It varies from 2,000-horse power to 10,000-horse power, according to the diameter of the tube in process of manufacture. The revolutions of the flywheels in the machines are so numerous that such wheels are usually made of large discs inside which and around the hub wire is tightly wound to give the necessary weight. Cast-iron flywheels would fly apart, and have, indeed, done so on several occasions before they were discarded.

A mandrel may be used when exactness of internal diameter is required [11] and when a tube of small diameter and heavy gauge is being made into one of larger diameter and thinner gauge. The Mannesmann process produces tubes of very high tensile strength. Figure 12 shows a different form of revolving cones.



12. MANNESMANN PROCESS

The Stiefel Process. The Stiefel process deserves mention as it has points of resemblance to the Mannesmann process. Two opposing discs mounted upon revolving vertical shafts parallel to each other and not in the same plane have faces with circumferential bevels. The hot billet is made to pass between these discs and on to a pointed mandrel placed in position, which pierces it in its progress. Suitable guide blocks are placed to keep the billet in its path.

Large Steel Tubes. Tubes of very large diameter have been made by a process of rolling subsequent to a rough drawing. The maximum size made hitherto by this process is 10 ft. long and 8 ft. in diameter, and there is no reason why the diameter at least could not be made much greater if it were desired. Such tubes have been used for rings for locomotive boilers, cylinder linings for hydraulic presses, and other purposes where high tensile strength is imperative, and where formerly the structures had to be made of plates curved and welded or riveted.

The process consists first in piercing a steel billet of suitable size into tubular form, and then of inserting a roller not shorter than the size of the tube desired, and rolling the tube already made, thereby increasing its diameter circumferentially as the shell is attenuated.

Die Press Process. Another process of tube manufacture consists in pressing discs of metal in a die press until after successive operations they evolve from flat shape to cup shape, then becoming longer, thinner, and of smaller bore under suitable pressing dies until they assume the ultimate form desired. This mode of manufacture is suitable for objects such as cartridge cases, and steel cylinders for gas, which in their final form are to have one end closed. They are thus cylinders rather than

tubes. The open end is, if necessary, narrowed or closed by compression, or, in the case of heavy iron or steel cylinders, the object may be made in two halves, which come together sectionally, and are united by welding.

Lock-joint Tubing. Various attempts have been made to manufacture lock-joint tubing, and the problems involved present no great difficulties. The usual practice is by rolling processes and through formers which bend around the edges of the strip into suitable shape, so that one edge may engage the other. Then the edges are brazed or soldered [see Soldering]. The manufacture of such tubing is limited, and is seldom used for making iron and steel tubing.

Taper Tubes. For some purposes taper tubes are desired. In the case of locomotive boiler tubes, for instance, they may be made parallel outside, but tapering inside, and therefore of heavier gauge at one end than at the other end. This is done in order that the thicker end may be placed where it is subject to greatest heat, and the thin end where the heat is less intense and the thickness superfluous. Brass and copper tubes are made with an internal taper by drawing them upon a taper mandrel the entire length of the tube, and by stripping them from this mandrel. Iron and steel tubes with internal taper are made by different processes. Ricketts' method provides that, in the process of drawing tubes through dies and over a bulb-headed mandrel, the mandrel should be made of slightly tapering form, and should have a very slow longitudinal travel, working automatically after the manner of the automatic feed on a drilling machine. Thus the space between the mandrel taper and the die, which space decides the gauge of the tube, is gradually widened, thereby producing a tube of gradually increasing gauge, and therefore with internal taper.

Heavy iron and steel tubes, such as are used as standards for electric lights and for electric railways are made by using as a die a pair of rollers provided with circumferential grooves with gradually increasing sweep. These rollers revolve in unison, and as they do so the die formed by the two grooves, while always remaining circular, increases in size, thus making the tube taper.

Annealing Tubes. In drawing tubes cold through dies as in wire drawing, the drawing process hardens nearly all metals, rendering them incapable or extremely difficult of further drawing and to reinvest them with the necessary ductility annealing is necessary. The annealing chambers, as we saw in considering wire drawing, are simply ovens of suitable size, and into these the articles are placed and maintained at a high temperature. Annealing, under the usual conditions, demands that the object annealed should be afterwards "pickled"—that is, immersed in a solution of hydrochloric acid (usually one part to 39 of water). This pickling removes the oxide of iron which the annealing has caused to appear on the surfaces of the tubes. Many attempts have been made to dispense with the necessity for pickling, and what is termed "bright annealing" is a not uncommon process. In bright annealing, the articles in the annealing ovens are annealed not surrounded by air as in the common process but by some gas which does not have the oxidising influence of the air. In some cases the annealing oven is put into communication with a coal gas supply service. By admitting the gas the air is expelled and the articles are then annealed without the formation of scale, maintaining their original brightness.

Other devices adopted include special methods of pickling. One process attempted removes the scale electrically by making the tubes anodes in an almost neutral bath, and by introducing lead or iron plates as cathodes.

Brass Tubes. The production of brass tubes is very large. Such tubes were formerly made by the primitive hand method, in which a strip of sheet metal was cut to the necessary width and bent around an iron rod. The edges of the partially-formed tube were then bound together with rings of wire, solder and borax were placed along the seam and fused in a common forge or under a blowpipe. Then, after being soldered, the tube was hammered round the rod upon which it had been formed, fullers being used in the process.

The present-day process of making tubes of brass and other metals gives results much better than the original method mentioned. Strips of metal of a suitable width are cut. In the case of large tubes demanding thick sheets the strips are put longitudinally through rolls—one concave and its fellow convex. By this device the strips are made into long channels the section of which is curved. Then, by beating it with a hammer, the end of the tube is tapered. The drawing tool is placed in position in the draw bench, and the tapered end, or tang, is passed through it. The draw tongs are made to grip the latter, and put into motion by means of the chain, which drags them along the bench, pulling the metal strip through the dies, and giving it the form of a tube with a seam up one side. Then the *wirer*—that is, a workman, or often a workwoman, responsible for the next operation—binds the edges together by encircling the tube with rings of iron wire at a distance of 2 in. apart. Then another operator, called the *charger*, places along the seam some *spelter*, or brass solder, in granulated form and mixed with borax.

The crude tube so prepared is now placed in a soldering stove, which must be of a suitable length. When it has been raised to a red heat, the brass solder and the borax fuse and unite the two sides, making the tube complete except for the finishing processes.

The binding wires are removed when the tube has cooled, and the surplus solder is removed by filing or grinding. Then pickling in weak acid cleans off the adhering dirt and the tube is again passed through a die on the draw bench. If a tube of absolute accuracy—internally, as well as externally—be demanded, a smooth mandrel is placed inside it before it receives this final drawing, and the drawing die, offering pressure to this resisting mandrel, makes a tube smooth in surface and uniform in gauge both internally and externally.

Solid Drawn Brass and Copper Tubes. The ingot which is to make brass or copper tubes must be carefully made, and certain precautions are necessary. It must be sound metal, and must have a sound face, or the chance of a good tube resulting is small. Clean metals poured into warm moulds should give the desired result. If the moulds are cold, and the cores warm, the latter will draw moisture, giving unsound ingots, in addition to which there is a danger of some of the metal blowing out of the mould. Usually, the casting is done in iron moulds set vertically and with warm cores. Mould and cores should be coated with plumbago or chalk, the former for preference.

Welsh coke is the best fuel, but if gas coke be used, it should be clean, or impurities may be carried into the metal.

With alloys of zinc, the heat should not be raised too high, or the composition of the alloy may be altered somewhat, and if exact specification be demanded, this may be bad. The flux used in making alloys must depend upon the constituents of the alloys, but it ought to produce a metal in a clean fluid state, and with melting temperature as low as possible.

A little lead, especially if it contain a percentage of silver, will make the process of rolling and drawing much more easy, and it is worth adding, but only a small quantity will enter into the alloy, any excess above this quantity squeezing out in cooling.

The hollow ingot, having been cast, is placed upon a mandrel and pulled through successive dies, each smaller than that preceding. Sometimes the mandrel is stationary as well as the die, and the tube is drawn between the two. Between each drawing the tubes are annealed and pickled, this being necessary to re-impart the ductility required.

Copper Tubes by Electric Deposition. Copper tubes are made by electrolytic deposition as well as by the mechanical process described. The chemical purity of electrolytic copper is well known, and when the plant is arranged to deposit the copper in the form of a tube there is a great saving of mechanical operations. Tubes made by this process are able to stand very severe tests. They may be doubled close cold and then doubled over; they may be doubled close cold and then opened out, and they may be expanded and flanged with a flange three times the diameter of the tube—all without splitting or showing defects.

In the process of manufacture the copper is deposited upon a mandrel. For tubes up to 4-in. inside diameter the mandrel is of brass, and for larger sizes it is of cast iron, with a brass neck to take the current. The cast-iron mandrels, previous to use in the tube depositing tanks, are immersed in an alkaline electrolytic bath, containing sheet copper anodes, where they receive a thin covering of copper. The alkaline bath is kept at a slight heat. All the mandrels, whether of brass or of cast iron, are covered with plumbago, so that the finished tube may be easily removed after deposition.

The anodes used in the depositing bath are made from copper bars, which have been refined to remove arsenic and other impurities, and are practically pure copper. They are cleaned with diluted sulphuric acid before immersion in the depositing tanks. In operation the copper anodes and the mandrels are placed in the tank, the latter nested alongside of the anodes and resting on insulated supports at both ends. Acid sulphate enters the tank by gravitation from suitable reservoirs. The positive current reaches the copper anodes through lead conductors, and the negative current reaches the mandrels through copper conductors and flexible brushes. The mandrels revolve during the process, while agate burnishers travel along the whole length, giving to the tube uniform density and a surface of mirror smoothness. The coated mandrels after removal from the tank are treated in a tube expanding machine, and in a power draw-bench, which pulls the tube from its mandrel. Sometimes the tubes are subsequently drawn to different dimensions to those in which they leave their mandrels, and in this event they must be afterwards annealed and pickled.

Aluminium Bronze Tubes. Aluminium bronze is specially suitable as a material for tubes, for water-tube boilers, condensers, and acid industrial works. Its ability to resist corrosion is excelled only by gold and platinum, and its electric potential is almost nil. Aluminium bronze tubes are often drawn by the Mannesmann process, already described. To attempt to draw them on draw benches commonly used for drawing brass and copper tubes is to spoil the dies, which are not strong enough to resist the hardness and high tensile strength of the alloy. During the process of drawing, aluminium bronze tubes require frequent annealing.

Brass-cased Tubes. Much of what looks like brass tubing is only iron tubing covered with brass. Great economy is effected by substituting this so-called *brass-cased* tubing for solid brass tubing. Instances of its use are brass bedsteads and brass curtain poles. The latter are usually, however, of brass entirely when they are bent to fit oriel windows. The methods of making brass-cased tubing is ingenious and simple. The iron tubing is made from hoop or strip iron in the manner we have already described except that the butting edges are not usually brazed, welded, soldered, or otherwise joined. Then a tube of brass larger in its internal diameter than the external size of the iron tube is made in the same manner. The iron tube is put within the brass tube. It enters easily, being smaller. Then the two together are put on the draw bench and pulled through the die, which compresses the brass tube in diameter and extends it longitudinally. This mere pressing of the brass tube upon the iron tube gives sufficient adhesion for all purposes to which brass-cased tubing is usually put. Sometimes the brass tubing is brazed before being drawn down on the iron tube, but for some purposes this is not done. If we examine the brass-cased tube that serves for the head rail in a cheap iron bedstead, we shall probably find that the underside shows a seam. This is because, for considerations of price, the brass tube has not been brazed at its edges.

Tubes of Odd Section. Tubes of odd form, such as square, oval, D-shape, triangular, fluted, or polygonal, are made simply by making the drawing die and the mandrel the necessary shapes. They present no difficulties greater than those in drawing ordinary round tubing. When tubes other than round are desired to be made with their section spirally to the length, making thereby what are called *twisted tubes*, the tool through which they are drawn, in addition to being of the desired form, is made to revolve. It is geared to the wheels that operate the drawing mechanism, and thus a uniform number of twists can be given throughout the length of the tube. The tool in this case really acts like a screw-plate, putting a thread on the tube pulled through it. Many forms of ornamental tubing, such as are much used for gas pendants and other gas fittings, lamp standards, etc., are made by passing brass tubing through hard metal rollers containing grooves cut with the desired pattern. A solid brass tube is supported inside with a mandrel, so as to offer resistance to the pressure of the rollers, and by passing tube and mandrel through the machine the desired design is imparted to the tube.

Lead Pipe. Lead pipe, or pipe made of an alloy of which lead is the principal constituent, and termed *compo* pipe, is used largely in domestic plumbing work. The former practice of making lead pipes was to bend strips of lead round a mandrel and to solder the edges together. Such

a practice has long been discarded, except where the small plumber makes his own traps, and pipes of lead are now forced by pressure through a hole or die the size of the external diameter of the pipe being made, and having in its centre a mandrel the size of the internal diameter of the pipe required. The power used is usually hydraulic, and the machine is a hydraulic press. The usual charge of lead is between 2 cwt. and 4 cwt., and this is poured in a molten state into the chamber. Pressure is applied before the lead has quite cooled, so that it is to some extent plastic. Sometimes a furnace surrounds the chamber, so as to keep the lead at its proper temperature as the pipe is being made. The smallest size of lead pipe—⅜ in.—is usually made in from 30 to 40 yard lengths, and large sizes—from 2½ to 6 in.—in 12-ft. lengths.

Extruded Tubes. An account of tube manufacture would be incomplete without notice of tubes produced by Dick's extrusion process, which is worked by the Delta Metal Company. It is really the process used in manufacturing lead pipe, by pressing it through a die applied to working alloys in a molten state. The machine which is called into use consists essentially of a cylinder and a hydraulic ram. The heated metal, usually an alloy of copper, is poured into the cylinder, at one end of which is the die. Upon the application of pressure from the opposite end, the plastic metal issues through the die as a rod or tube, conforming in section to the shape of the die. The chief use of this process is in making bars or rods of odd sections, which could not be rolled; but many articles of tubular formation are also made. In their case, a mandrel is placed within the die, and this gives the form to the internal diameter of the article to be extruded. Successful operation of this process is due to the fact that the alloys that are treated may be separated into more than one stream when in a plastic condition, and will reunite readily and perfectly under simple pressure if no air has been admitted to oxidise the fresh surfaces created. This separation takes place in the cylinder, because the metal is broken into two or more streams as it passes the arch that holds the mandrel in position; but a reunion takes place before the metal comes to the die. Alloys of copper are usually extruded at the temperature of plasticity, which is about 1,000° F. For small work, the cylinders are fitted with several dies—up to four in number—and four tubes or rods are produced simultaneously.

Flexible Metallic Tubing. The desirability of having flexible tubing much stronger and more durable than is possible with indiarubber admitted flexible metallic tubing into immediate favour, and new spheres of usefulness are continually being found for it. It is made by the United Flexible Metallic Tubing Company, Limited. It is largely used in railway work for water-fed pumps from the engine to the tender and for heating carriages. In countries of extreme temperatures, that cause rubber to perish within a short time, flexible metallic tubing is extremely valuable. Rock drills actuated by compressed air often have the air supplied to them through this variety of tubing with excellent results. It has also been used to pump liquid fuel in the form of petroleum from one vessel at sea to another while both were going ahead at almost full speed, thereby saving a good deal of time in ocean voyages. These are merely a few of the many uses to which flexible metallic tubing is now put.

The process of manufacturing flexible metallic tubing demands great care, and the resulting tubing must fulfil two conditions—it must be flexible and it must be water and air tight, even, in some cases under high steam pressure. It would be easy to make it flexible at the expense of the latter quality, and it would be easy to make it airtight at the expense of flexibility. To serve its purposes, however, it must have as much flexibility as is consistent with absolute airtight qualities.

Making Flexible Metallic Tubing. The first thing necessary in manufacturing the tubing shown in **13** is an extremely tough, and, at the the same time, highly ductile metal strip or ribbon

13 FLEXIBLE METALLIC TUBING

of absolutely uniform width and of very great length. This ribbon—of steel, brass, copper, zinc, or, indeed, any metal sufficiently ductile—is drawn through successive formers, which gradually shape it from the flat strip into a sort of double tube having the section of the figure 8, only the ends turned over do not butt close up to the central web. The final process is that of coiling this strip in a spiral form round a core, causing the lower part of each spiral to engage the upper part of the spiral to which it is united, thus forming the tube. In this operation the tension of the strip, the accurate adjustment of the metal surfaces, and the mode of release from the core or mandrel upon which the tubing is made, are the matters of chief moment. All these operations are accomplished in a single machine, which receives the plain metal strip and delivers the tubing complete and ready for use. Very long tubes can be made by the process described, the length being limited only by the limitations of the strip that can be supplied to the machine. Thus, to make a tube ⅜ in. in diameter requires strip $\frac{1}{10}$th millimetre thick and 14 millimetres in width, and the limits of length for metal strips of this section is from 6,000 ft. to 7,000 ft. It requires 10 ft. of strip to produce 1 ft. of tube, and this gives 600 ft. to 700 ft. lengths of tubing of the size mentioned. When tubing is required in greater length than this, these long strips are united by electric welding, so that there is no practical limit to the length that may be supplied in one piece.

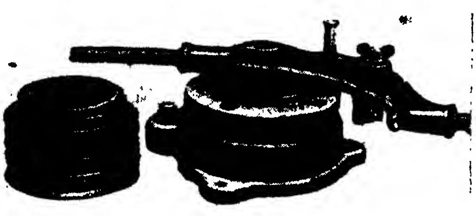
For steam purposes, flexible metallic tubing is made of copper, pure or alloyed; for use in pumping oil, and other purposes, steel is used; brass tubing is provided for locomotive work, and for use as gas tubing in making flexible connections, both steel and zinc are employed. For suction as well as for use under compression, this tubing is excellent.

Gas Fittings. An important use to which tubing is put is the manufacture of gas fittings. Into the many forms of gas fittings space will not permit us to enter. We can record only the present tendency of the trade. Undoubtedly the invention of Auer von Welsbach—the incandescent gas mantle (see GAS)—gave to gas lighting a hold which it was gradually relaxing, and postponed the general adoption of electricity as a domestic illuminant. The tendency of taste in modern gas fittings is away from the sliding water-sealed chain and weight gaselier towards fixed pendants and brackets, and to pendants that can be raised and lowered without a water-sealed tube. The popularity of the inverted gas mantle is creating

a demand for new styles and new designs in gas fittings, and at present there is no evidence that fixity of design has been attained or that the problems of construction have been properly solved.

In gas fittings, soft or tinman's solder is avoided, and hard soldering or brazing is adopted. Ornamental tubing, such as we have already noted is used extensively for gas fittings, but even here there is a distinct tendency towards plain, round tubing, and to lightness and grace contrasted with ornament and elaboration. Mountings of gas fittings are to a great extent stamped brass work. Taps, swivels, and couplings are, of course, cast brass, and are made chiefly by semi-automatic machines. Ingenuity is being exercised in the finishing of gas fittings, and fashion, to some extent, holds sway here.

Tube Bending. Cast-iron pipes, of course, cannot be bent at all. Wrought iron and steel tubes are often filled with sand, heated to redness, and bent round a shape, the welded side being kept at the inside of the bend. Brass tubes for curtain-poles and other purposes are filled with pitch, and, when cold, bent round something of a suitable shape. Then the tube is heated, and the pitch remelted and poured out. This demands that the tube must be repolished. A coil-spring mandrel is also used for bending tubes for cycle and other work. The mandrel is screwed up to its minimum diameter and inserted into the tube. Then, by turning a key at its extremity, it is distended inside the tube as far as the internal diameter of the latter will permit, and the bend is made, the mandrel resisting the flattening at the bend which would otherwise take place. The mandrel is again screwed up tightly and withdrawn. This method cannot give very sharp bends, and the spring mandrels are expensive and somewhat brittle.



14. KENNEDY'S TUBE-BENDING MACHINE

Some machines have recently been invented for the purpose of bending tubes, and perhaps the best is Kennedy's patent [**14**], which is now used by several Government departments. It consists essentially of a circular plate grooved on its periphery to suit the tube to be bent. A plate of the proper size is placed on a vertical centre, and a hard steel grooved block, mounted upon a lever and made to describe an arc parallel to the periphery of the plate, is pressed against the outer side of the tube, thus making the bends. By a sufficient number of grooved discs, and a machine of the proper capacity, this machine gives a very wide range of bends that may be made and sizes of tubes that may be handled. The weld—if the tube be of the welded variety—should be on the inside of the bend. In the largest size, the power is applied manually by a worm and wheel arrangement.

Measurement of Tubes. The measurement of brass and copper tubes is calculated upon the outside diameter, and tubes of iron, steel, lead, and composition, or *compo* tubes or pipes, by the inside diameter. The reason for the apparent anomaly is that brass and copper tubes are used largely for purposes where the external size is the important consideration, and that the chief purpose of the tubes of other metal is to pass water, gas, or steam where the quantity that the pipe or tube will take is the important point. The result of this method of calculating size is that tubes—say, ½ in. diameter for gas, water, and steam respectively—look very different from each other in external diameter.

It is the practice of most tube-makers to manufacture welded tubes for water one gauge thicker than gas tubes, and steam tubes again are one gauge thicker than water tubes. The usual gauges, thicknesses, and weights of the three varieties of tubes and the number of threads per inch in the screws used for them are given in the table that follows:

WROUGHT-IRON TUBES FOR GAS, WATER AND STEAM

Bore* in Inches.	Screw Threads per Inch.	GAS			WATER			STEAM		
		S.W.G.	Thickness in Inches.	Pounds Weight per foot.	S.W.G.	Thickness in Inches.	Pounds Weight per foot.	S.W.G.	Thickness in Inches.	Pounds Weight per foot.
¼	19	14	·080	390	13	·092	·419	12	·104	·448
⅜	19	13	·092	·560	12	·104	·627	11	·116	·694
½	14	12	·104	·840	11	·116	·924	10	·128	1·008
¾	14	11	·116	1·176	10	·128	1·288	9	·144	1·400
1	11	10	·128	1·680	9	·144	1·848	8	·160	2·016
1¼	11	9	·144	2·464	8	·160	2·632	7	·176	2·800
1½	11	8	·160	3·136	7	·176	3·472	6	·192	3·808
1¾	11	8	·160	3·463	7	·176	3·804	6	·192	4·145
2	11	8	·160	3·791	7	·176	4·137	6	·192	4·483
2½	11	7	·176	5·334	6	·192	5·846	5	·212	6·350
3	11	7	·176	6·350	6	·192	6·936	5	·212	7·563
3½	11	7	·176	7·309	6	·192	8·020	5	·212	8·732
4	11	7	·176	8·047	6	·192	8·767	5	·212	9·488

A Dictionary of Technical Terms used in Metals and Metal Manufactures appears at the end of the Self-Educator.

Consignments Inward and Outward. Mutual Indebtedness of Countries. The Par and Course of Exchange. Gold Movements. The Bill Market.

FOREIGN BILLS AND EXCHANGES

It is now more than ten years since the attention of the people in the United Kingdom was particularly drawn to the whole question of our trade with foreign countries. This is not the place in which to enter into a discussion of the merits of the two fiscal systems which for some time were argued by leading men on both sides, but if the raising of the subject has had the effect of making our manufacturers and merchants alive to some of the defects in their methods of conducting their foreign trade, undoubtedly a very useful purpose will have been accomplished.

Imports and Exports. The importance of the subject is not likely to be under-estimated, but it may be mentioned that in 1913 our foreign trade amounted to £1,294,000,000, of which £769,000,000 represented imports and £525,000,000 exports. The difference in value between the imports and exports is known as the balance of trade, and it was formerly held that in order that a country should be in a prosperous condition the exports should always exceed the imports. This idea no longer holds the field in its original shape, attention being now directed more to the nature of the articles making up the total than to the totals themselves—*i.e.*, whether they consist of raw or manufactured goods. Considerations of space forbid a lengthy explanation of the methods of conducting the foreign trade of the country generally, and our purpose here is to deal with the matter from the view of accounts.

There are three principal methods of selling goods—*viz.*, direct, at auction, and on commission. The method with which we shall now deal is the one last mentioned, since the first has already been the subject of our various examples hitherto, and the second is really covered by the others. Most of the goods exported by our merchants are in execution of orders received from abroad—*i.e.*, they are sold before they leave this country; but other transactions are entered into where no sale has taken place before the goods are exported, and where the object in sending them is to endeavour to find a buyer in the place to which they are sent. The goods are despatched to an agent in the town or country in which the merchant hopes to find a market for them, arrangements having first been made with the agent as to the terms upon which he will act. These terms are generally reimbursement of his out-of-pocket expenses, and a commission by way of a percentage upon the selling price of the goods.

Consignments Outward. The goods sent out by a merchant in this manner are termed in his books a *consignment outward*, while the same goods are referred to in the books of the agent who receives them as a *consignment inward*. The merchant, who is known as the *consignor*, keeps an account in his books of the cost of the consignment, both as regards the price of the goods and the expenses incurred. He does this because he desires to know the outcome of each consignment, whether it results in a profit or a loss, so that he can form an opinion whether it would be advisable to send further consignments to the same place or to the same agent. When a large consignment business is done a special book is kept in which to record all goods sent out in this way. The book is treated in the same manner as a sales book, the entries in it being posted periodically to the ledger. When there is only an occasional transaction of the kind the entry can be passed through the journal, debiting the consignment account and crediting goods account.

Consignment Accounts. A ledger account is required for each consignment, to record the separate results as well as the net result of the whole. The consignments are, therefore, numbered or given distinguishing titles according to either the place to which they are sent or the consignee's name. If accounts of consignments outward are distinguished by the names of the consignees it must be borne in mind that they are merely subsidiary goods accounts and not personal accounts upon which the consignees are liable. The first entry on the account is on the debit side, and consists of the price of the goods. As payments are made in connection with the consignment, the account is debited and cash credited. Any liability incurred in connection with it is debited to the account and credited to the person or firm to whom the amount of the liability is due.

A *pro forma* invoice is made out and sent to the agent, with instructions as to the minimum price at which he is to sell. If he is successful in his efforts and disposes of the consignment, he prepares and forwards to the consignor a statement called an *Account Sales.* This shows the gross amount realised, details of his expenses and commission, and the net amount due to the consignor. This amount he remits to him in the manner dealt with later.

The consignor enters the amount of the net proceeds as shown by the account sales on the credit side of the consignment account, the balance on which will then represent his profit or loss on the venture. The reason for this is that the total cost, both in goods and expenses, will appear on the debit side, and the net amount realised on the other. The difference is, naturally, the gain or loss.

The consignee terms the goods a *consignment inward.* If he acts as agent for a number of merchants, or has many consignments from one merchant, he keeps a special book in which he records particulars of all goods so received. This record will usually be merely a memorandum, and no entry will be made in a book of account upon the receipt of the consignment. The reason for this is that the goods do not, on the one hand, belong to the consignee, and therefore cannot be debited to the goods account; while, on the other, the consignor is not his creditor for the value of the goods, since the consignee has not bought them and is not liable for the price. He is only responsible for their safe custody and for the proceeds if he effects a sale. If he is not successful in this he can return the goods. As a rule, then, no account is opened by a consignee when he receives goods on consignment, but as soon as he pays anything or incurs any liability in respect of it he records the fact in his account books. He does this by opening an account in his ledger in the name of the consignor (not a consignment account, but a personal account), and debits the amount paid or the liability incurred. The reason for this is that the amount is due from a definite person, and he naturally debits that person and not an impersonal account. At the same time, he credits cash or the person to whom the amount is due.

When a sale is effected the consignee debits the person to whom the goods have been sold and credits the consignor, because the amount then becomes due to the latter, subject to the payments or charges which may have been incurred on his account. The consignee then calculates his commission and debits the amount to the consignor, who, of course, is liable to pay it. The balance on the consignor's account will then represent the amount due to him, since he has been debited on one side with all payments made or expenses incurred on his behalf and with the agreed commission, while he has been credited, on the other side, with the gross proceeds of the goods. The consignee then remits the balance due, usually by a bill of exchange, and the method by which he does so is explained later. When the purchaser of the goods pays for them, cash is, of course, debited and the payer credited. This will close the transaction in the consignee's books.

For the purpose of making the course and result of the operations clear to the mind of the student, a series of transactions will be dealt with and the ledger accounts shown in the books of both the consignor and the consignee. W. Brown, of London, ships to J. Bonhomme, of Bordeaux, ten bales of 400 yards each of cotton goods at 8d. per yd. and pays £15 for freight, £2 13s. 4d. for insurance, and £6 5s. 3d. for cartage and miscellaneous charges. Bonhomme receives the goods, and pays £3 for storage, £1 for insurance, £10 for Customs duties and landing charges, and £3 for miscellaneous expenses. He sells four bales at 1s. per yd., and the other six at 1s. 0½d. per yd. His commission is 2½ per cent. on the proceeds. Bonhomme's payments and transactions, taking place in Bordeaux, will naturally be in French currency, but for the sake of simplicity they are given in the accounts in sterling.

They are, however, for the guidance of the student shown in the account sales on the next page in French currency just as they would appear in the statement as rendered by Bonhomme. It will be observed that the balance shown by account sales to be due to W. Brown is stated therein both in French currency and in its British equivalent.

The following are the accounts as they would appear in the two ledgers.

W. BROWN'S LEDGER

Dr. — Consignment to J. Bonhomme, Bordeaux — Cr.

Date	Particulars	£	s.	d.	Date	Particulars	£	s.	d.
1905 July 1	To Goods	133	6	8	Sept. 6	By Bill receivable for net proceeds as per Account Sales	182	17	6
„ 2	„ Cash, Cartage, etc. ..	6	5	3					
	„ „ Insurance ..	2	13	4					
	„ „ Freight	15	0	0					
Sept. 30	„ Net Profit transferred to Profit and Loss Account	25	12	3					
		£182	17	6			£182	17	6

J. BONHOMME'S LEDGER

Dr. — A/c of W. Brown — Cr.

Date	Particulars	£	s.	d.	Date	Particulars	£	s.	d.
1905 July 9	To Cash, Duties & Landing	10	0	0	July 31	By F. Martini, 4 bales @ 1s.	80	0	0
	„ „ Storage	3	0	0	Aug. 31	„ „ 6 bales @ 1s. 0½d.	125	0	0
	„ „ Insurance ..	1	0	0					
	„ „ Miscellaneous ..	3	0	0					
	„ Commission % ..	5	2	6					
	„ Bill payable for balance as per Account Sales	182	17	6					
		£205	0	0			£205	0	0

Foreign Exchanges. The words relating to the payment of the balance due to the consignor, as shown on the account sales, brings us to the general question of the foreign exchanges. The consignee, being a Frenchman, naturally keeps his books in the currency of his own country, and renders accounts to his English consignor in the same way, merely remitting the ultimate balance due in English money. We have now to inquire how he does this, and how he arrives at £182 17s. 6d. as being a fair equivalent of 4,608 fr. 45 c. He could, no doubt, have purchased English gold and silver coins to the amount he has to remit, but obviously this would be a clumsy and costly method of discharging the liability, and is no more adopted in practice between foreign countries and England than it is between two towns in the same country.

The remittance, as stated in the account sales, is made by a bill of exchange, and the bill is obtained by the consignee finding somebody in Bordeaux who has a debt due to him from a person in England and purchasing the right to receive payment of such debt. Let us take a simple illustration to see how this is brought about, and how the indebtedness of two persons to two others, on perhaps many transactions, can be settled by one payment. A in Bordeaux buys goods from B in London, while C in London buys goods from D in Bordeaux. We will assume that the amount is the same in both cases. D draws a bill upon C for the amount the latter owes him. A becomes aware of this and buys the bill from D for its fair equivalent in French money. Having obtained the bill he sends it to B in London, who presents it to C, and in due course receives payment from him.

ACCOUNT SALES OF 10 BALES OF COTTON SOLD FOR ACCOUNT OF W. BROWN, OF LONDON

W B			Per yd	Fr.	c.	Fr.	c.
1–10	4	Bales 1,600 yards @	1.26			2,016	
	6	„ 2,400 „ @	1.31¼			3,150	
						5,166	
		CHARGES					
		Customs Duties and Landing Charges		252			
		Storage		75	60		
		Insurance		25	20		
		Miscellaneous		75	60		
		Commission @ 2½%		129	15	557	55
						4,608	45

Bordeaux, 1st September, 1905
Jean Bonhomme
Bill at 3 months herewith @ 25.20 = £182 17 6

Par of Exchange. We now come to the question of what is a fair amount in French money to pay for a given amount of English money. To obtain the answer we must know the state of the currency of each country, what is its standard coin and of what metal it is composed. In England, of course, the standard coin is the gold sovereign. It contains a certain quantity of alloy for hardening purposes, the proportion of pure gold in the sovereign being eleven parts in twelve. In France the standard coin is the franc, but as this is a silver coin the value of French money as compared with English is measured by the 20-franc piece, which is of gold. The fineness of this coin—*i.e.*, the proportion of pure gold in it, is nine parts out of ten. There is thus a small difference in favour of the English currency in the proportion of pure gold in the coins of the two countries; and although it is trifling in one coin it becomes of great importance when large amounts are involved, and has to be taken into account when stating the quantity of French coins which are required to make up the value of the English sovereign.

A further point which has to be taken into consideration in fixing the relative values is the difference in the weight of the sovereign and of the 20-franc piece. The sovereign weighs 123·27 gr., the 20-franc piece 99·56 gr. Obviously, then, we shall require more than 20 francs for one sovereign, and after taking both weight and fineness into consideration, it is found that the English pound is equal to 25·2215 francs, or, roughly, 25 fr. 22 c. This is known as the *par of exchange* between France and England, and is the basis upon which settlements of account between the two countries take place.

But although it is the basis, there are many considerations which help to raise or lower the rate. Owing to the very considerable trade between England and France, there are always thousands of debts outstanding between the traders in the two countries which have to be settled in some way. This mutual indebtedness is made the means of satisfying the claims on both sides without any coin passing to and fro. Of course, it happens that gold is imported from or exported to France as well as other countries, but the quantity bears no relation to the volume of trade between those countries and England. There being, thus, many people in England indebted to others in France, while there are people in France indebted to others in England, it is clear that if a transfer of the debts could be arranged so that the English debtors could pay the English creditors, while the French liabilities were discharged in a similar manner, an immense saving of trouble and expense would be brought about, while the claims on both sides would be satisfied. This

is, in effect, exactly what takes place, and the means by which it is effected are bills of exchange. [See page 988.]

Foreign Bills. For practical purposes foreign bills of exchange are treated as a commodity, and there is a regular market in them as in other articles of commerce. The dealers in this market are known as *bill brokers*, and they make it their business to buy and sell bills drawn on persons in this country by creditors in other countries, and vice versâ. If, therefore, a person in London desires to satisfy a debt to another in Paris or Berlin, he approaches a bill broker and ascertains the price he will have to pay for a bill for the amount he requires. The principal bill brokers, bankers, and merchants meet twice a week at the Royal Exchange and fix the rates for bills on the various countries. The basis of the rate is, as stated above, the par of exchange; but there are many causes operating to affect the market rate. The principal of these is the condition of trade between the two countries. If there is, on balance, a considerable indebtedness from England to another country, there will necessarily be a strong demand in London for bills payable in that country, and the prices of bills of exchange, like those of other commodities, are affected by the laws of supply and demand. The result will be that the English trader will have to pay a premium for the bill he requires, but the premium will be stated in such a way as somewhat to confuse the student in the absence of explanation.

The par of exchange between London and Paris is, as stated above, 25 fr. 22 c. for £1. The rate is said to be above par in London when the exchange is quoted below 25·22, the reason being that in exchange for a sovereign it will be possible to obtain only, say, 25 fr. 15 c., and thus, to discharge an indebtedness in French money a higher price than the actual mint value will have to be paid in English currency.

Gold Points. But there are certain points above or below which the rates with other countries do not rise or fall. These are known as the *gold points*, and indicate the rates at which it would be more profitable to import or export gold coin or bullion to discharge debts rather than buy bills at prices outside those limits. The gold points depend upon the cost of transmitting the gold, plus insurance and other expenses, and the margin, therefore, varies according to distance and other circumstances. In the case of London and Paris, the point at which it would pay to export gold to France is 25·12½—*i.e.*, if it were found that the price of bills was 25 fr. 10 c. a merchant could send bullion cheaper than he could obtain bills. The importing point is 25 fr. 33 c., so that a merchant in Paris would send gold to England if bills on London were above that rate. Although these are theoretically the points of gold movements, it might not follow that gold would be transferred if the rates of exchange exceeded these limits, for the cost of transmission fluctuates slightly, and might do so sufficiently to prevent shipment.

Foreign Bill Procedure. The procedure with regard to foreign bills of exchange differs from that in the case of inland bills. The form of the bill is different, and, as a rule, the wording is as follows:

LONDON, 1*st July*, 1906.

Exchange for Fcs. 7,550.

STAMP 1/6

At three months after sight of this first of exchange (second and third unpaid) pay to the order of M. Jules Perier seven thousand five hundred and fifty francs and place same to our account as advised.

WILLIAMS, JENKINS & CO.

M. F. Chardenal, Marseilles.

Foreign bills are drawn in the currency of the country of the drawee, and are prepared in sets of three. The three parts are in identical terms, except that each is expressed to be payable only in the event of the others being unpaid. The chief reason for drawing the bills in sets was originally with a view to their reaching their destination safely, and that is one reason why they are still so drawn. Another reason is the facility which the method affords for negotiating the bill. The drawer, a merchant carrying on business, say, in Bombay, draws on his debtor in London, and sends over two parts of the bill for acceptance by different mails. He keeps the third, and if he finds subsequently that it would be of advantage to him to have cash immediately, he takes the bill to his banker, and discounts it with him, endorsing it in the usual way. The banker then sends the endorsed part, which, of course, has not been accepted, to his agent in London, who obtains one of the other parts from the drawee duly accepted. The accepted and endorsed parts then form a complete bill, and will be collected when due. The drawee must be careful not to accept more than one part, for if he should do so, and both accepted parts got into the hands of holders for value, he would be liable to pay both.

Frequently when a creditor in one country draws on his debtor in another, he sells the bill as soon as it is drawn, and the name then inserted in the body of the bill as the payee is that of the person who buys it—generally a banker or bill broker. It will be perceived from this that foreign bills are sold or discounted by the drawers before they have been accepted. This is what actually takes place in many cases, and bills frequently pass through several hands before they are presented to the drawee for acceptance.

Acceptance for Honour. In order to guard against the risk of the drawee refusing to accept the bill when it is presented to him for that purpose, the drawer or any subsequent holder may write on the bill, "In case of need with Blank & Co." This means that in case of the bill being dishonoured owing to its not being accepted by the drawee, the firm named will accept the bill to protect the honour of the drawer or subsequent holder as the case may be. Before they will do so, however, a form has to be gone

through, known as *protesting the bill.* This consists in the bill being formally presented for acceptance by an officer known as a Notary Public, who afterwards makes a declaration in a stated form that he has done so. When a bill is accepted in this way it is known as an *acceptance for honour.*

The banker, or bill broker, who buys a bill from the drawer treats it as part of his stock-in-trade, and either holds it until maturity, or sells it before it is due to somebody who wishes to pay money in the place where the bill is payable.

Payable After Sight. It will be observed that the bill set out on last page directs payment three months *after sight.* This means that the time mentioned in the bill will not begin to run until it has been accepted or sighted by the drawee. Foreign bills are frequently drawn after sight rather than after date, owing to the time which elapses before the drawee receives them for acceptance. When this is the case the bill is presented for acceptance as soon as possible after it is drawn, and the date it is accepted is included in the form of acceptance.

To return to the transaction out of which this short explanation of the principles of foreign exchanges and bills arose. We know that the course M. Bonhomme would take would be to buy from his banker in Bordeaux a bill on London for the amount he has to remit, the price being calculated at the rate of the day. Having obtained it, he sends it to Mr. Brown, who will probably first have to obtain acceptance of it, and then either hold it till it matures or else at once discount it.

Bank Drafts. Another method of making remittances abroad is to purchase a bank draft, which is an order by a banker upon an agent or a branch for the payment of a stated sum of money to the person named in the draft. The drafts can be made payable either at once or at a future time, but in practice they are nearly always sight drafts—*i.e.*, payable at sight or on demand in just the same way as a cheque. They are largely used when remittances of cash have to be made between countries.

English houses which are doing a large business with a manufacturer or merchant in a foreign country will frequently receive the invoices of the goods they buy made out in the currency of the country. The indebtedness will, of course, have to be discharged to the full amount of the invoices. When invoices are received in this form it is necessary for the English house to keep the account with the foreign merchant in both sterling and the foreign currency, the former in order to bring the transactions into line with the other accounts of the business, the latter to know exactly how they stand with the creditor. The method adopted is to fix a rate of exchange at which all invoices received are converted into sterling, the amounts being shown side by side in the ledger accounts. When remittances are made, drafts in the foreign currency are purchased at the rate of exchange of the day, and the cost in sterling and the amount of the draft are entered side by side on the debit side of the account. Finally, a draft is remitted for the difference shown by the currency columns, which will then exactly balance. This result will, however, probably not be obtained in the sterling columns, owing to the varying rates at which the drafts have been purchased. The difference on this column is treated as a profit or loss on exchange, and is carried away to the profit and loss account. The account given on this page shows the working of this method.

Dr. JONATHAN & CO., BALTIMORE Cr.

Date	Particulars	Fo.	$ c.	£ s. d.	Date	Particulars	Fo.	$ c.	£ s. d.
					1906				
Jan. 8	To Cash @ $49\frac{1}{2}$	65	250 00	51 11 3	Jan. 1	By Goods ..	41	250 26	52 2 8
,, 31	,, ,, @ $49\frac{5}{8}$	75	150 00	31 0 4	,, 28	,, ,, ..	63	180 48	37 12 1
Feb. 28	,, ,, @ $49\frac{3}{4}$	84	300 00	62 3 9	Feb. 21	,, ,, ..	93	320 76	66 16 5
Mar. 31	,, ,, @ $49\frac{11}{16}$	96	257 00	53 4 2	Mar. 6	,, ,, ..	114	85 00	17 14 2
	,, Gain on Exchange..			1 7 11	,, 18	,, ,, ..	130	120 50	25 2 1
			957 00	£199 7 5				957 00	199 7 5

The fixed rate adopted in this instance for converting the dollar into English money is 50d. per dollar, and the invoices are posted in both currencies, as shown above. Remittances of bank drafts on Baltimore were made on January 8th and 31st, and on February 28th, the drafts being purchased at different rates, as quoted in the account. After making these remittances, there was a balance of 257 dollars due to the American firm, the cost of a draft for which was £53 4s. 2d. The invoices having been converted at a different rate from those at which the drafts were purchased, there is naturally a difference between the sterling columns. This, as stated above, is transferred to the profit and loss account, and if there are many accounts with such differences on them, a special exchange account is opened, and the balance thereof transferred to the profit and loss account at the periodical balancing of the books.

J. F. G. PRICE

A Special Dictionary explaining Commercial Terms and Phrases appears at the end of the Self-Educator

Products of Compound and Simple Expressions, and Compound Expressions with each other. Homogeneous Expressions. Squares and Cubes.

ALGEBRAIC MULTIPLICATION

PRODUCT OF A COMPOUND AND A SIMPLE EXPRESSION

25. We must first prove that $(b+c)\times a = ba + ca$, whether a be a positive integer, or a fraction, or negative.

(i.) If a be a positive integer

Then, by definition,

$$(b+c)\times a = (b+c)+(b+c)+(b+c)+\ldots \text{ taken } a \text{ times},$$
$$= b+b+b+\ldots \text{ taken } a \text{ times}.$$
$$+ c+c+c+\ldots \text{ taken } a \text{ times},$$
$$\therefore ba+ca.$$

(ii.) Since division is the inverse of multiplication, it follows from (i.) that to divide $(b+c)$, treated as a whole, by a positive integer, gives the same result as dividing b and c separately by that integer.

Therefore, if a is a positive fraction, equal, say, to $\frac{m}{n}$, we have

$$(b+c)\times a = (b+c)\times\frac{m}{n},$$
$$= \frac{mb+mc}{n}, \text{ from (i.)},$$
$$= \frac{mb}{n}+\frac{mc}{n}, \text{ since the division of } (mb+mc) \text{ by } n \text{ may be performed on } mb \text{ and } mc \text{ separately},$$
$$= b\times\frac{m}{n}+c\times\frac{m}{n},$$
$$= ba+ca.$$

(iii.) If a be negative, equal, say, to $-m$.

Then, by definition, to multiply $(b+c)$ by a we must do to $(b+c)$ what we do to 1 to obtain $-m$; *i.e.*, $(b+c)$ must be subtracted m times. Thus,

$$(b+c)\times a = -(b+c)-(b+c)-(b+c)-\ldots m \text{ times},$$
$$= -b-b-b-\ldots m \text{ times},$$
$$= -c-c-c-\ldots m \text{ times},$$
$$= -bm-cm,$$
$$= b\times(-m)+c\times(-m),$$
$$= ba+ca.$$

These results are evidently independent of the values of b and c.

Hence, for *all values* of a, b, and c, we know that

$$(b+c)\,a = ba+ca.$$

26 Since the result is true for *all* values of a, b, c, it will be true when $b = p+q$.

Therefore,

$$(p+q+c)\,a = (p+q)\,a+ca,$$
$$= pa+qa+ca.$$

Proceeding in this way, we find that $(p+q+r+s+\ldots)\,a = pa+qa+ra+sa+\ldots$ is true, however many terms there may be in the expression $p+q+r+s+\ldots$

But, it is clear that *any* compound expression can be written in the form $p+q+r+s+\ldots$

For example, the expression

$$5x^3-3x^2\div y+6z$$

in which the *terms* are (i.) $5x^3$, (ii.) $-3x^2\div y$, and (iii.) $6z$, becomes $p+q+r$ if we write p for $5x^3$, q for $-3x^2\div y$, and r for $6z$.

Hence, *to obtain the product of a compound expression and a simple expression, we take the sum of the products formed by multiplying the separate terms of the compound expression by the simple expression.*

Example **1**. Multiply a^2-3a+2 by a^2.

We have

$$a^2\times a^2 = a^{2+2} = a^4$$
$$-3a\times a^2 = -3a^{1+2} = -3a^3$$
$$2\times a^2 = 2a^2,$$

remembering to apply the law of signs to each product.

The whole process is performed mentally, and all that need be written is

$$(a^2-3a+2)\,a^2 = a^4-3a^3+2a^2 \quad \underline{Ans.}$$

Example **2**. Multiply $2x^2y+7xy^3-3x^2y^2$ by $-3xyz$.

$$(2x^2y+7xy^3-3x^2y^2)(-3xyz)$$
$$= -6x^3y^2z-21x^2y^4z+9x^3y^3z \quad \underline{Ans.}$$

Example **3**. Simplify

$$3a-2\,[2b+3\,(a-2b)-2\,(b-a)]$$

The given expression

$$= 3a-2\,[2b+3a-6b-2b+2a],$$
$$= 3a-4b-6a+12b+4b-4a,$$
$$= -7a+12b \quad \underline{Ans.}$$

Here, a number outside a bracket means that, on removing the brackets, we must multiply every term between the brackets by that number. The rest of the process is the same as in Art. **20**.

PRODUCT OF TWO COMPOUND EXPRESSIONS

27. Suppose in Art. **26** that the value of a is $(x+y+z+\ldots)$. We shall now be able to find the value of the product

$$(p+q+r+\ldots)\times(x+y+z+\ldots).$$

For, we have,

$$(p+q+r+\ldots)\times(x+y+z+\ldots)$$
$$= (p+q+r+\ldots)\,a,$$
$$= pa+qa+ra+\ldots,$$
$$= p\,(x+y+z+\ldots)$$
$$+ q\,(x+y+z+\ldots)$$
$$+ r\,(x+y+z+\ldots)+\ldots$$
$$= px+py+pz+\ldots$$
$$+ qx+qy+qz+\ldots$$
$$+ rx+ry+rz+\ldots$$
$$+\ldots$$

Hence, *to obtain the product of two compound expressions we take the sum of the products formed by multiplying every term of the one expression by every term of the other.*

Example 1. Multiply $3x + 4y$ by $-x + 2y$.

The product

$= (3x + 4y) \times (-x + 2y)$,

or, as it is usually written [Art. 2],

$$\begin{aligned}&(3x + 4y)(-x + 2y)\\ &= (3x)(-x) + (3x)(2y) + (4y)(-x) + (4y)(2y),\\ &= -3x^2 + 6xy - 4xy + 8y^2,\\ &= -3x^2 + 2xy + 8y^2 \ \underline{Ans.}\end{aligned}$$

The work is generally arranged as follows,

$$\begin{array}{llll} 3x & +4y & & \\ -\ x & +2y & & \\ \hline -3x^2 & -4xy & & \\ & +6xy & +8y^2 & \\ \hline -3x^2 & +2xy & +8y^2 & Ans. \end{array}$$

Explanation. Write the multiplier under the multiplicand. Multiply every term of the multiplicand by the first term, $-x$, of the multiplier as in Ex. 1. of Art. 26. Next, multiply every term of the multiplicand by the second term, $+2y$, of the multiplier, writing "like" terms of the two products in the same columns. Finally, add the two lines, as in Ex. 1. Art. 15.

28. When the multiplier and the multiplicand consist of terms containing different powers of some common letter, it will be found convenient to arrange the terms in the following way:

In each expression put the term which contains the highest power of that letter first, the term which contains the next highest power next, and so on. This is called *arranging the expression according to descending powers of that letter.* The expression $3x^3 - 2 + 4x^2 - x + 5x^4$, when arranged according to descending powers of x, becomes $5x^4 + 3x^3 + 4x^2 - x - 2$. In a similar way we may arrange an expression according to *ascending* powers of some particular letter. For example, if we arrange $y^4 - x^3y + 2xy^3 - 5$ in ascending powers of y, we obtain $-5 - x^3y + 2xy^3 + y^4$.

It should be remembered, however, that this rearrangement of the terms, before beginning the multiplication, is not absolutely *necessary.* The reason for doing so is that it saves some trouble in getting the like terms of the product into the proper columns.

Example. Multiply $3x^3 - xy^2 + 2y^3 - 4x^2y$ by $y^2 + x^2 - 2xy$.

$$\begin{array}{llllll} 3x^3 & -4x^2y & -xy^2 & +2y^3 & & \\ x^2 & -2xy & +y^2 & & & \\ \hline 3x^5 & -4x^4y & -x^3y^2 & +2x^2y^3 & & \\ & 6x^4y & +8x^3y^2 & +2x^2y^3 & -4xy^4 & \\ & & 3x^3y^2 & -4x^2y^3 & -xy^4 & +2y^5 \\ \hline 3x^5 & -10x^4y & +10x^3y^2 & & -5xy^4 & +2y^5 \ Ans. \end{array}$$

Explanation. We have here arranged both expressions in descending powers of x. Note that by so doing we have also arranged them in ascending powers of y. We then work from left to right, multiplying first by x^2, then by $-2xy$, then by y^2, finally combining the like terms as in addition.

DIMENSIONS OF EXPRESSIONS

29. When a simple expression consists of the product of n letters, it is said to be *of n dimensions,* or, *of the nth degree. Numerical* factors do not affect the degree of an expression.

Thus, a^2, that is aa, is of two dimensions, or of the second degree. $5x^2yz$ is of the fourth degree, since it consists of the product of four letters, $xxyz$.

The degree of a compound expression is the degree of the term of highest dimensions contained in it. For example, $2a^3b - 4abc + c^2$ is of the fourth degree, since the term of highest dimensions, $2a^3b$, is of the fourth degree. But, in speaking of the degree of an expression, we sometimes only take one particular letter into account.

Thus, $2a^3b - 4abc + c^2$ is of the *third degree in* a. It is of the *first* degree in b, and the *second* degree in c.

An expression of the second degree is often called a *quadratic expression.*

HOMOGENEOUS EXPRESSIONS

30. *A homogeneous expression* is one in which all the terms are of the same dimensions.

$5x^7 - 3x^5yz + y^3z^4$ is a homogeneous expression of the seventh degree, since each term is of the seventh degree.

We have seen in Art. 27 that any term in the product of two multinomials is obtained by multiplying a term of the one multinomial by a term of the other. It is clear, then, that if each of the multinomials is homogeneous, their product will be homogeneous. For example, if every term of the multiplier is of the *second* degree, and every term of the multiplicand is of the *third* degree, then every term of the product will be of the *fifth* degree, since $2 + 3 = 5$. See the Example in Art. 28. If every term in the product was not of the fifth degree, then we should know there was a mistake in our multiplication.

PRODUCTS BY INSPECTION

31. The student must learn to write down the product of two, or of three, such factors as $x + a$, $x + b$, $x + c$, without going through the process explained in Art. 27.

If we do the actual multiplication we find that

$$(x + a)(x + b) = x^2 + ax + bx + ab,$$

which may be written

$$x^2 + (a + b)x + ab.$$

This result will be true whatever values a and b may have. A *general* result, such as the one just shown, is called a *formula.*

Let us now give special values to a and b. Suppose $a = 3$ and $b = -2$. Then we have

$$\begin{aligned}(x + 3)(x - 2) &= x^2 + (3 - 2)x + 3(-2)\\ &= x^2 + x - 6.\end{aligned}$$

Or, if $a = -7$ and $b = 4$, we get

$$\begin{aligned}(x - 7)(x + 4) &= x^2 + (-7 + 4)x + 4(-7)\\ &= x^2 - 3x - 28.\end{aligned}$$

We see, then, that the product of two such binomials as $x + 6$ and $x - 5$ consists of three terms, and that (i.) the first term is x^2; (ii.) the coefficient of x is the *sum*, taken with their

proper signs, of the second terms of the binomials; (iii.) the third term is the *product* of the same two terms.

In the same way, by actual multiplication, we find that the product of $x+a$, $x+b$, and $x+c$ is

$$x^3+(a+b+c)\,x^2+(bc+ca+ab)\,x+abc.$$

Hence we can at once write down the product of three such binomials as $x+2$, $x-1$, $x+4$.

Thus,

$$\begin{aligned}&(x+2)(x-1)(x+4)\\ &=x^3+(2-1+4)\,x^2\\ &\quad+\{2(-1)+4(-1)+2\,.\,4\}\,x+2\,.\,4\,.\,(-1)\\ &=x^3+5x^2+2x-8.\end{aligned}$$

After a little practice, the second line of work can be performed mentally, so that we have nothing to write down but the actual result.

SQUARE OF A MULTINOMIAL

32. We shall now show how the square of any multinomial can be written down by inspection.

In the formula

$$(x+a)(x+b)=x^2+(a+b)\,x+ab,$$

if we put $b=a$, we obtain

$$(x+a)^2=x^2+2ax+a^2.$$

That is, *the square of a binomial is equal to the square of the first term, plus the square of the second, plus twice the product of the two terms.*

Example 1. Write down the square of $2a-3b$.

Here, we have

$$\begin{aligned}(2a)^2&=4a^2,\\ (-3b)^2&=+9b^2,\\ 2\,(2a)\,(-3b)&=-12ab.\end{aligned}$$

all of which can be done mentally, so that,

$$(2a-3b)^2=4a^2-12ab+9b^2\ \ \underline{Ans.}$$

In the formula $(x+a)^2=x^2+2ax+a^2$, suppose a is equal to $(y+z)$. Then we have

$$\begin{aligned}(x+y+z)^2&=x^2+2\,(y+z)\,x+(y+z)^2\\ &=x^2+2xy+2xz+y^2+z^2+2yz\\ &\quad\text{or, rearranging the terms,}\\ &=x^2+y^2+z^2+2yz+2zx+2xy.\end{aligned}$$

Proceeding in the same way, we can obtain a formula for the square of the sum of *any* number of quantities. We may express the result in words, thus,

The square of any multinomial is equal to the sum of the squares of each term of the multinomial, together with twice the product of every pair of terms.

Example 2. Square $a+2b-3c$.

$$(a+2b-3c)^2=a^2+4b^2+9c^2-12bc-6ca+4ab\ \ \underline{Ans.}$$

Note that, whatever signs the terms of the given expression may have, the "square" terms of the result must, by the rule of signs, always be positive. We do not, therefore, have to trouble about the signs of the result until we come to the part which consists of "twice the product of every pair of terms."

After writing down the square of a multinomial, we must, if there are any like terms, collect them according to the ordinary rules.

Example 3. Find the value of $(x^3-x^2+x-1)^2$.

The required value

$$\begin{aligned}&=x^6+x^4+x^2+1\\ &\quad-2x^5+2x^4-2x^3-2x^3+2x^2-2x\\ &=x^6-2x^5+3x^4-4x^3+3x^2-2x+1\ \ \underline{Ans.}\end{aligned}$$

Note. To make sure that we take *every* pair of terms, it is best to take "twice the product of every term into *every term which follows it.*"

CUBE OF A BINOMIAL

33. The student should also remember the *cube* of a binomial. We can obtain it from the formula

$(x+a)\,(x+b)\,(x+c)=x^3+(a+b+c)\,x^2+(bc+ca+ab)\,x+abc$ by putting b and c each equal to a. Thus,

$$\begin{aligned}(x+a)^3&=x^3+(a+a+a)\,x^2+(aa+aa+aa)\,x+aaa\\ &=x^3+3ax^2+3a^2x+a^3.\end{aligned}$$

Example. Write down the value of $(2b-1)^3$.

Here, the x of the formula becomes $2b$, and the a becomes -1. Therefore,

$$\begin{aligned}(2b-1)^3&=(2b)^3+3\,(-1)\,(2b)^2+3\,(-1)^2\,(2b)+(-1)^3\\ &=8b^3-12b^2+6b-1\ \ \underline{Ans.}\end{aligned}$$

The working should, of course, be performed mentally, nothing but the result being written down.

34. Before leaving multiplication, there is one other important result to be obtained from the formula

$$(x+a)\,(x+b)=x^2+(a+b)\,x+ab.$$

Suppose $b=-a$. Then we get

$$\begin{aligned}(x+a)\,(x-a)&=x^2+(a-a)\,x+a\,(-a)\\ &=x^2-a^2.\end{aligned}$$

Hence, *the product of the sum and difference of two quantities is the difference of their squares.*

EXAMPLES 5

Multiply

1. $x^2-xy+3y^2$ by $3x^2y$.
2. x^3-y^3+1 by $-4xy$.
3. $a^2y^2-abx^2+acz^2-2bcyz+2c^2xy$ by $-5abcxyz$.
4. x^2-xy+y^2 by $x+y$.
5. x^2+xy+y^2 by $x-y$.
6. x^2+ax-a^2 by x^2-ax+a^2.
7. x^3-2x+3 by $x-1$.
8. x^3+ax^2-bx-c by x^2-ax+b.
9. $3x^2y^2-x^4+2y^4$ by y^2-x^2+xy.
10. $a^2-ab-ac+b^2-bc+c^2$ by $a+b+c$.

Using the result of Art. **34** find the continued product of

11. $1-x,\ 1+x,\ 1+x^2$.
12. $x^2+xy+y^2,\ x^2-xy+y^2,\ x^4-x^2y^2+y^4$.

Simplify

13. $(a+b+c)\,(b+c-a)\,(c+a-b)\,(a+b-c)$.
14. $(x-y)^2+(y-z)^2+(z-x)^2$.
15. $(x+2)\,(x+3)\,(x+4)\,(x+5)$.
16. $x^2y^2\,(p^2-q^2)+p^2q^2\,(x^2-y^2)+p^2y^2\,(q^2-x^2)+q^2x^2\,(y^2-p^2)$.
17. $9\,(x-3)\,(x+3)+2\,[(x-2)^2-\{2\,(x-4)\,(x+5)+3\,(x-1)^2\}]$.

Find the following squares

18. $(x-3y+4z)^2$.
20. $(a+b-c-d)^2$.
19. $(3a^2-2a+5)^2$.
21. $(a+b)^2(a-b)^2$.

Find the cube of

22. $3x-y$.
24. $x+y+z$.
23. $1-4a$.
25. $x-y-z$.

DIVISION

35. Division is the inverse of multiplication. When we divide 6 by 2, we find the quantity by which 2 must be multiplied in order to produce 6. Similarly, when we divide a by b, we find the quantity by which b must be multiplied to produce a.

Now, in Art. **22**, we saw that successive multiplications can be done in any order. Therefore, successive divisions can be done in any order. Hence, a succession of multiplications and divisions can be done in any order. For example, if we multiply a by b, and divide the product by c, we obtain the same result as if we divide a by c and multiply the quotient by b.

36. In Art. **21** we saw that

(i.) $(+a)\times(+b) = +ab$.

Therefore

$(+ab)\div(+a) = +b$.

(ii.) $(+a)\times(-b) = -ab$.

Therefore

$(-ab)\div(+a) = -b$,

and

$(-ab)\div(-b) = +a$.

(iii.) $(-a)\times(-b) = +ab$.

Therefore

$(+ab)\div(-a) = -b$.

On examining these results we see that, just as in the case of multiplication, "like signs give +, unlike signs give –." Thus, *the Law of Signs is the same for division as for multiplication.*

37. In Art. **23** we showed that $a^3 \times a^4 = a^7$. If, then, we divide a^7 by a^3, we obtain a^4 for quotient.

That is,

$$a^7 \div a^3 = a^4 = a^{7-3}.$$

Therefore, *when one power of a letter is divided by another power of the same letter, the index of the quotient is found by subtracting the index of the divisor from the index of the dividend.*

38. We are now able, by using these results, to divide one simple expression by another.

Example 1. Divide $14x^3y^4$ by $7xy^2$.

$14x^3y^4 \div 7xy^2 = (14\div7)\times(x^3\div x)\times(y^4\div y^2)$ by Art. **35**.

$= 2\times x^{3-1}\times y^{4-2}$, by Art. **37**.

$= \underline{2x^2y^2 \ \textit{Ans.}}$

As in multiplication, it is clear that we can write down the result at once, the steps shown above being done mentally. We (i.) write down the sign of the quotient, (ii.) divide th numerical coefficient of the dividend by that c the divisor, (iii.) write down each letter tha occurs; the index of its power being found b subtracting the index of that letter in th divisor from the index of the same letter in th dividend.

Example 2. Divide $-15a^7b^4c^3$ by $3a^4b^2c^2$.

$-15a^7b^4c^3 \div 3a^4b^2c^2 = \underline{-5a^3b^2c \ \textit{Ans.}}$

Here we have "unlike signs give –." The $15\div3=5$. Next, $a^7\div a^4 = a^3$, and so on.

39. It should be noticed that when a pow of a letter is divided by the *same* power of th letter, our rule gives us 0 for the index of tl quotient.

Thus,

$$x^4 \div x^4 = x^{4-4} = x^0.$$

But it is evident that $x^4\div x^4$ is 1. Hence, quantity whose index is zero is equal to 1.

Answers to Algebra

Examples 3

1. $2a-[b-\{a-2b-a\}] = 2a-[b+2b] =$ $-3b$ *Ans.*

2. $3x-[1-\{3x+1-3x+1\}] = 3x-[1-$ $= 3x+1$ *Ans.*

3. $a+b-[-c+a+2b-a-c] = a+b+$ $-2b-a-b+2c$ *Ans.*

4. $-\{-1+1+2\}-[2+1-2-3] \quad -2+$ $=0$ *Ans.*

5. $x^4-x+3x^3+x^2+x-1-[-3+x^4+$ $+x^2+1] = x^4+3x^3+x^2-1+3-x^4-3x$ $-1=1$ *Ans.*

6. $\frac{1}{2}x-\frac{3}{2}y-\frac{1}{4}z-\frac{1}{2}x-\frac{1}{2}y+\frac{1}{4}z+x = x-$ *Ans.*

Examples 4

1. $28x^5$.
7. ab^2cxy.
2. $12x^4$.
8. $-20cx$.
3. $-2x^2y^2$.
9. $-60a^2b^2c^2$.
4. $-6a^5bc^4$.
10. $-6a^4b^3c^2x^3$.
5. $44a^2bc$.
11. $-x^3y^4z^3$.
6. $-2a^6b^7c^4$.
12. $-48ab^2c^2x^3y^2z^3$.

13. $2ax^2y = 2.(-1).4.3. = -24$ *Ans.*

14. $5a^2y^3 = 5.1.27 = 135$ *Ans.*

15. $3xy+4y^2z-5a^3 = -18+0+5 = -$ *Ans.*

16. $(2x+3y)^2-3(a^2+z^2) = (-4+9)^2$ $(1+0) = 25-3 = 22$ *Ans.*

17. $2ax-\{3x^2y-\overline{4xyz-a^3}\} = 4-\{36-0$ $= -31$ *Ans.*

18. $\sqrt[3]{6ax^5y^2} = \sqrt[3]{6.(-1).(-32).9} = \sqrt[3]{2}$ $= 2^2.3 = 12$ *Ans.*

19. $\sqrt[3]{\dfrac{a^2+xy}{5x^3}} = \sqrt[3]{\dfrac{1-6}{-40}} = \sqrt[3]{\cdot}$ $= \sqrt[3]{\dfrac{1}{8}} = \dfrac{1}{2}$ *Ans.*

20. $\sqrt{6ax^3y} \div \sqrt[4]{12a^2x^2y^3} = \sqrt{144} \div \sqrt[4]{}$ $= 12\div6 = 2$ *Ans.*

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